Air & Space

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Smithsonian Institution

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Navigating the Skies

Modern navigation: electronic technology in the British Aerospace Advanced Flight Deck. Information for the operation and navigation of the aircraft is displayed on a series of cathode ray tubes, similar to a small television set. In NASM's new Jet Aviation Gallery an advanced flight deck will be on exhibit which will demonstrate to the visitor an approach to London airport. (See page 12)

By the time the Wright brothers made their first flight in a heavier-than-air aircraft in 1903 the art of navigation was in a fairly advanced state, and large vessels were able to navigate across the major oceans with a high degree of accuracy.

But navigation was far from the minds of the two brothers from Ohio on that brisk December day on the beaches of Kitty Hawk. They merely wanted to get their Wright Flyer up in the air and prove that their dream was indeed a reality—and, as a matter of fact, that first flight by Orville lasted only 12 seconds and covered only 37 meters (120 feet). However, a new age had dawned, and it soon became evident that the airplane was going to be capable of flying great distances at high altitudes.

Navigating the skies was therefore about to become a critical factor in safe and reliable flight.

While some of the principles learned from our conquest of the seas could be applied to aviation, there were obvious differences between piloting a ship and piloting an airplane. For one thing, the airplane was faster. It was also more affected by the wind. And weather and visibility became more critical factors at altitude. Thus as the airplane itself was improved and developed over the past 75 years, so too was the vital art of aerial navigation.

At first, pilots navigated by the rudimentary practice of *pilotage*—that is, they guided themselves by reference to visible landmarks on the ground. They also began to use *dead reckoning* which was done by drawing vectors of the wind and the true airspeed and then computing the heading, groundspeed and estimated time of arrival at the destination. As late as 1927, Charles Lindbergh made his astonishing flight across the Atlantic by dead reckoning.

Celestial navigation was developed in which a sextant was used to measure angles to heavenly bodies. The new technology of radio was also enlisted, and navigation was made more sophisticated by a variety of radio aids. For instance, Jimmy Doolittle made the world's first instrument landing in 1929.

By World War II, radar, another important asset for aerial navigation, had made its appearance. Then computer technology was added to the science. All of those newer advances were used in one of the world's greatest navigation feats to date—the manned flight of Apollo 11 on its journey of some 383,024 kilometers (238,000 miles) from the launch pad at the Kennedy Space Center to the Moon, a four-day flight of unbelievable accuracy.

This issue of *Air & Space*—which features a number of articles about aerial navigation—reminds our readers that the ability to navigate the skies plays an essential role in our ongoing conquest of both air and space. ■

Navigation to the Moon: Neil Armstrong in the lunar module of Apollo 11.

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Air & Space combines information from many sources for a condensed overview of the history, science, technology, and social impact of selected aviation and space subjects.

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MUSEUM HOURS
Until March 31, the Museum will be open from 10 a.m. to 5:30 p.m.; starting April 1, Museum hours will be 10 a.m. to 9 p.m. The Museum is open to the public every day of the year except Christmas.

For brevity, the National Air and Space Museum is often referred to in these pages as NASM. The National Aeronautics and Space Administration is NASA.

Briefing

Aerial Navigation

Noel W. Hinners
Director, NASM

Aerial navigation has become extremely sophisticated, in a technological sense. Not so obvious are some of the broader aspects of navigation technology: for one thing, we continue to rely upon traditional navigational techniques which have been made more precise and accurate through modern technology; and furthermore aeronautical and astronautical navigation technology is proving useful for us in many diverse and very down-to-earth ways.

Consider first why we navigate. Very simply, it's to find out where we are, where we are going, how to get there and, frequently, how to return. Fundamental to all navigation is the existence of one or more reference points, places or things that can be clearly identified and whose location is known.

In the earliest days of exploration, landmarks served as reference points; one could find his way overland, point by point, by travelling, for example, "towards the middle peak of the mountain where the Sun rises."

When sailors first set sail on the oceans, they tried to stay within sight of shore and its recognizable landmarks. For later seafarers, the desire to head out into the distant oceans was tempered by the troublesome uncertainty of "Where am I?"

The invention of the chronometer in 1750 enabled navigators to determine longitude (east-west position) accurately. Nevertheless, it was not until the 20th Century that navigation became an exact science. We now have much better sextants—electronic star cameras on precision telescopes, and radio telescopes that take a fix on quasars at the edge of the universe. Inertial or gyroscopic navigation systems have largely replaced the magnetic compass in most ships and aircraft. Atomic clocks have replaced pendulum timepieces. We now emplace our own reference points—radio beacons on the ground and on satellites, laser reflectors on satellites and the Moon. Our maps are now accurate, in places, to tens of meters.

Using these new technologies, we can travel to faraway places, or find our location, with unerring accuracy. Pilots can fly airliners from New York to Paris without seeing the stars or the Earth from liftoff to touchdown. We can send the Voyager spacecraft on a 10-year trip of 3.2 billion kilometers (two billion miles) to close encounters of Jupiter, Saturn, and Uranus. Soon a new satellite system will instantly flash the location of downed aircraft to rescue teams, if those aircraft are equipped with a newly developed beacon. One can easily foresee the day when drivers will have inexpensive navigation systems in their automobiles that will continually show them where they are and how to get to their destinations.

Almost 500 years ago, Christopher Columbus knelt on the sandy beach of a tiny Caribbean isle he would later name San Salvador and gave fervent thanks to God for delivering him and his frightened crew to this tranquil shore. Columbus had discovered the New World; he did not know that he had missed his intended destination—the East Indies—by half the Earth.

The next time you see an airliner land after a transcontinental flight, or watch a spacecraft whiz by a distant planet halfway across our Solar System, on schedule, precisely where a team of scientists intended it to be, remember that pinpoint navigation made it possible.

A modern navigator in a military jet.

NAVIGATION

The art/science of aerial navigation

Capt. Walter Woodruff, USAF
Mather Air Force Base, CA

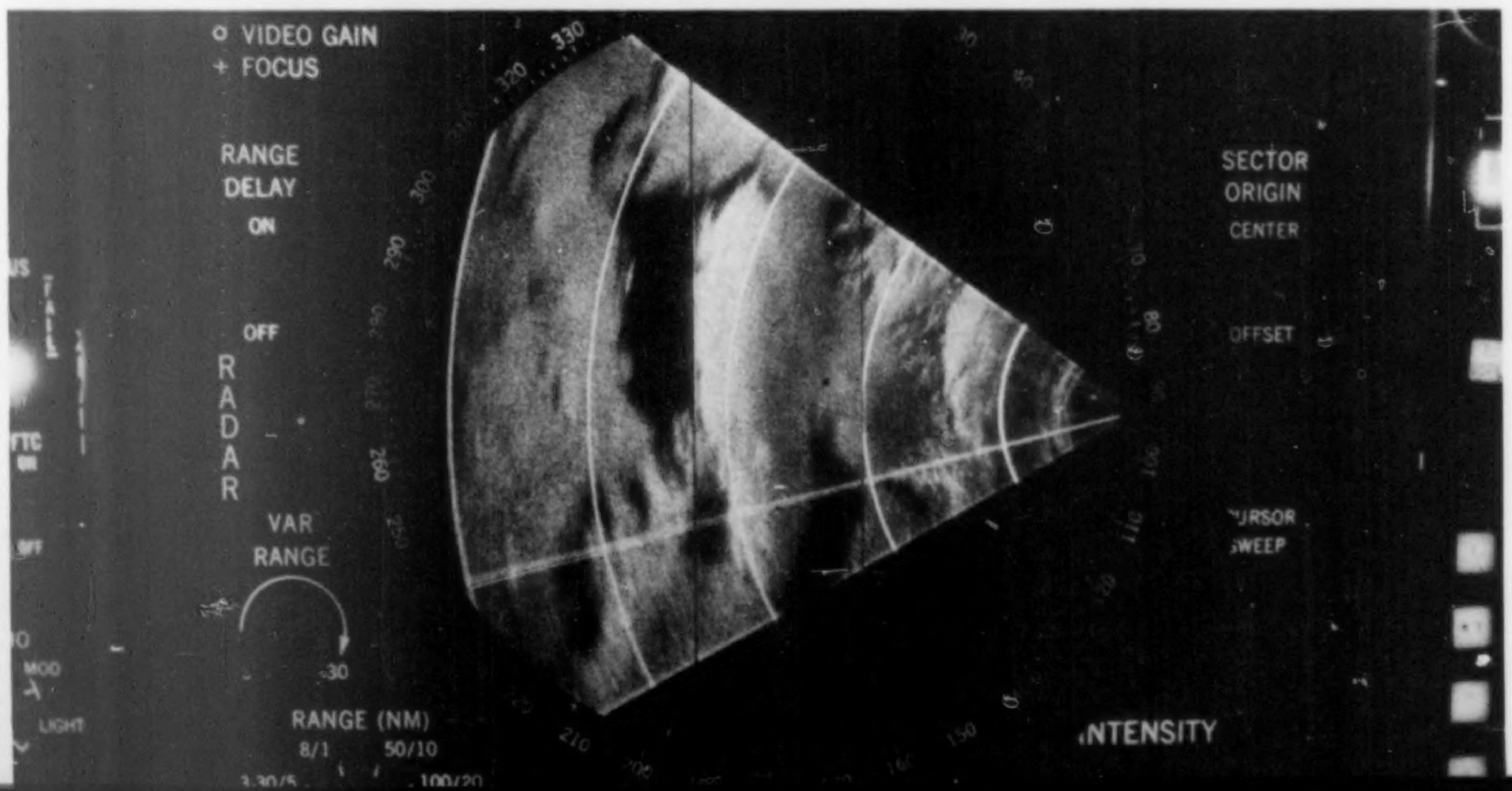
How do I get there? Which way do I turn? How long will it take? What time will I arrive? These questions have been asked by everyone from kids on the way to the candy store to astronauts on the way to the Moon. The basis of such questions is, of course, navigation, or getting from one place to another.

Navigation has been around as long as people have travelled, and by the turn of the 20th Century, maritime navigation had been greatly perfected. Ships could sail to any point on the globe, and mariners could be pretty sure of a safe and timely arrival at their destination. When the Wright Brothers made their first flight in 1903, aerial navigation was not a factor. Since the longest flight that day was only some 240 meters (800 feet) Wilbur and Orville could see their destination before they started. As flying machines became more powerful and reliable, aerial navigation became an item worthy of interest. The main navigation instruments in the early days were the pilot's eyes and a map. As the aircraft flew (usually at a relatively low altitude), the pilot merely looked down at the landmarks and compared them to the features on the map. Frequently even this was not necessary, for most folks stayed in the immediate area, not venturing more than a few miles from the field.

The first navigation instrument installed in aircraft was a magnetic compass. Once the early flyers ventured into unfamiliar territory, they had to have a directional reference. Thus, one could fly over a town, identify it, and proceed, say, due north until the next feature on the map appeared. Through the first World War, this method, called "map reading" or "pilotage" was the only type of navigation used. It worked very well most of the time, but there were some severe limitations. For one thing, when the ground was obscured, one had to make a best estimate of position until the ground was again visible. In many cases, the winds aloft were much stronger than forecast, and they blew aircraft miles off course, unbeknown to the crew. More than one crew has looked frantically for a recognizable landmark, and finding none, landed at the first available field. Night flying imposed severe handicaps on map reading, especially in sparsely populated areas. Perhaps the biggest disadvantage was the inability to fly long distances over water. (All water looks pretty much the same from the air.) If an overwater flight was attempted (such as Louis Bleriot's flight across the English Channel in 1909), the technique followed was: one last position, or "fix" was obtained by the pilot while still over land, and a planned compass course was flown over water. If the winds were as forecast, the pilot could be reasonably sure of finding a recognizable checkpoint upon reaching land again. This is the method (dead reckoning) that Lindbergh used in his 1927 flight.

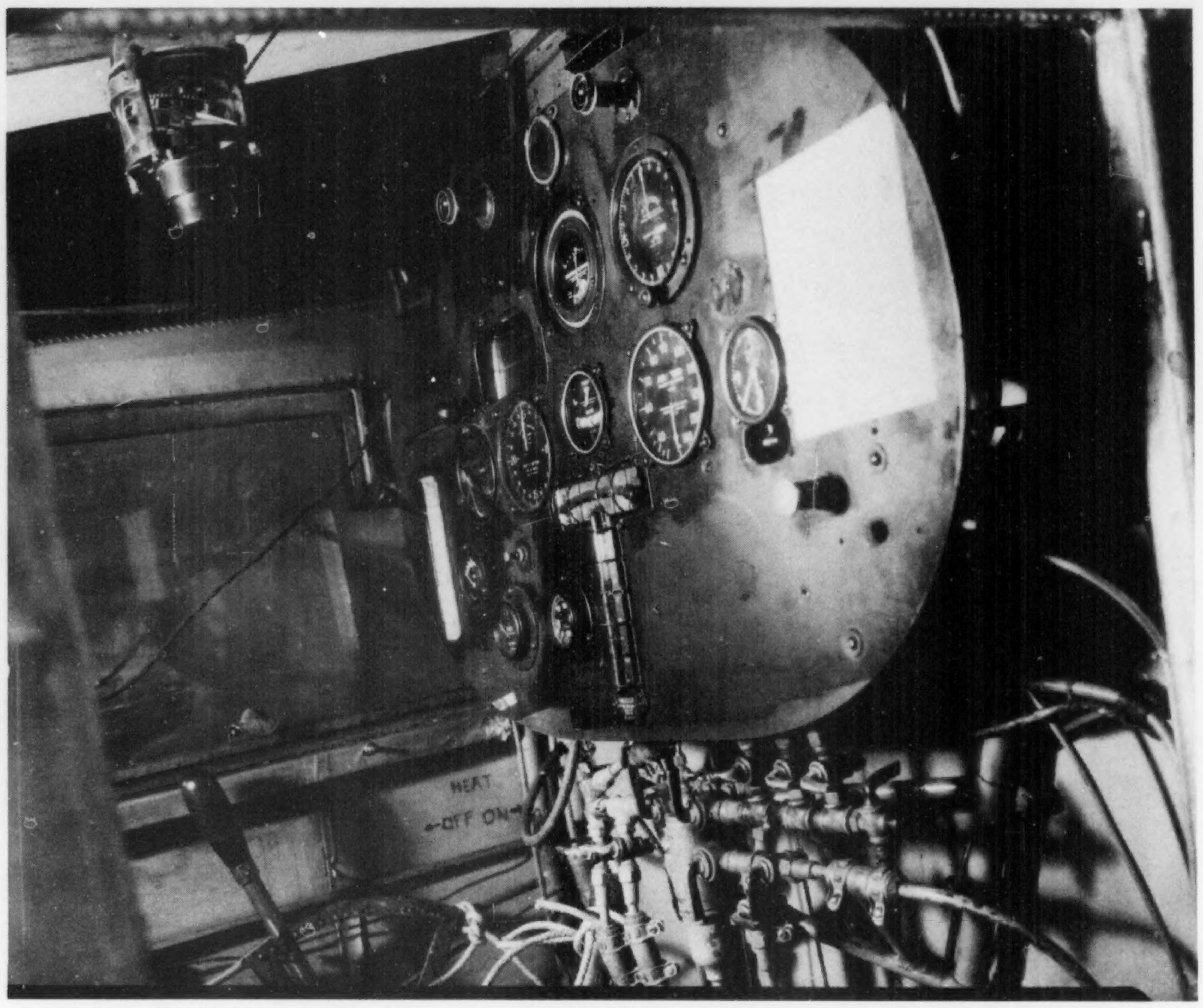
To overcome these limitations, a number of techniques and procedures were developed, and many pieces of equip-

Photo of a radar scope in operation. The curved lines are "range marks," and each one represents 16 kilometers (10 miles) distance from the point of origin at the right. The large object at 53 kilometers (33 miles) is a mountain.



ment were added to aircraft instrumentation. One of these, the sextant, permitted sightings to be taken on the Sun, Moon, or stars. Now, this technique had been used for thousands of years by maritime navigators, but adapting the sextant and celestial avigation to aircraft posed new challenges. First of all, the horizon can not be used as a reference in an aircraft as in a ship, due to weather and time of day. To overcome this, early aviators developed the bubble sextant in which a bubble similar to that in a carpenter's level is used as an artificial horizon. To compensate for the motion of the aircraft, a timing device was incorporated that permitted averaging an observation over two minutes. The basic premise of celestial navigation is simple; you estimate your position, then perform a series of calculations to determine how a particular celestial body would appear (angle above the horizon) from that position. An observation is then taken on the body, and the actual readings are compared with the predicted readings. The difference is converted to a line of position, and the navigator's location is on that line. Two bodies (Sun and Moon or two stars) can give two lines of position, and the observer's position is at the interception.

In an aircraft travelling at high speed, the aircraft covers an appreciable distance during the celestial observations, and in most cases, the navigator does some or all of the required calculations after the observation. Thus he knows where he was at the time of the shot, and must correct this position for aircraft motion. Celestial navigation is a time consuming, rather laborious process, and there are numerous chances for error. Nevertheless, it is a highly reliable aid, one that cannot be jammed or interfered with (as long as you can see the stars, of course).

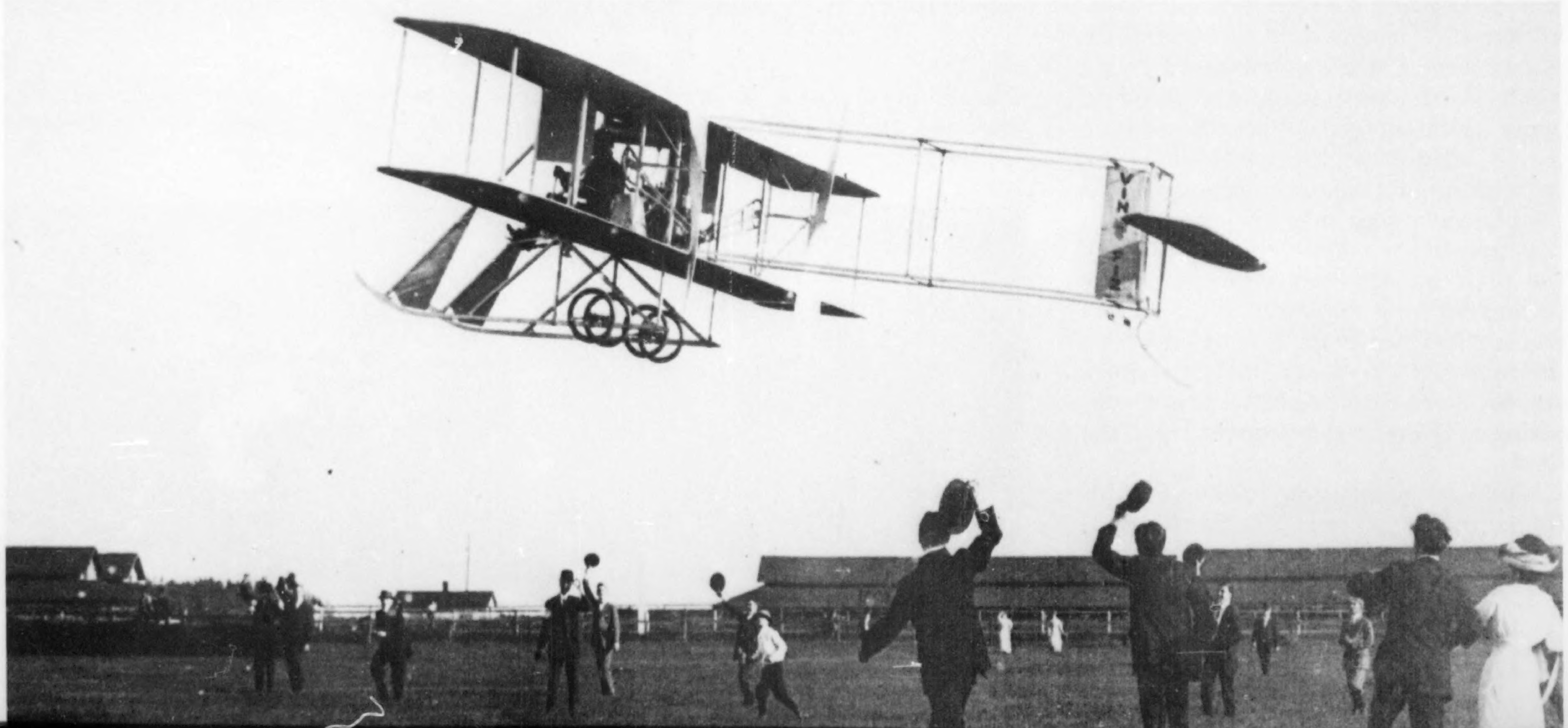


The cockpit of Lindbergh's Spirit of St. Louis. *The historic 1927 flight was made by dead reckoning. Note the suspended earth inductor compass at the upper left.*

Dead reckoning, map reading, celestial and primitive direction-finding radio aids were the primary methods up until World War II. Recognizing the need for fast, accurate inflight information, all the major powers began developing other navigation methods early in the war. At the beginning, it was apparent that the time-honored methods were just not working. For example, it is impossible to map read over the blacked-out landscape of enemy territory, and celestial navigation was impractical due to the time involved for calculations and the need for a steady flight platform—hard to do when the navigator had to fire one of the guns and the pilot took evasive action to avoid enemy flak and fighters.

One of the most important developments of the war was radar, or *RA*dio *D*etection *A*nd *R*anging. Briefly, a radar

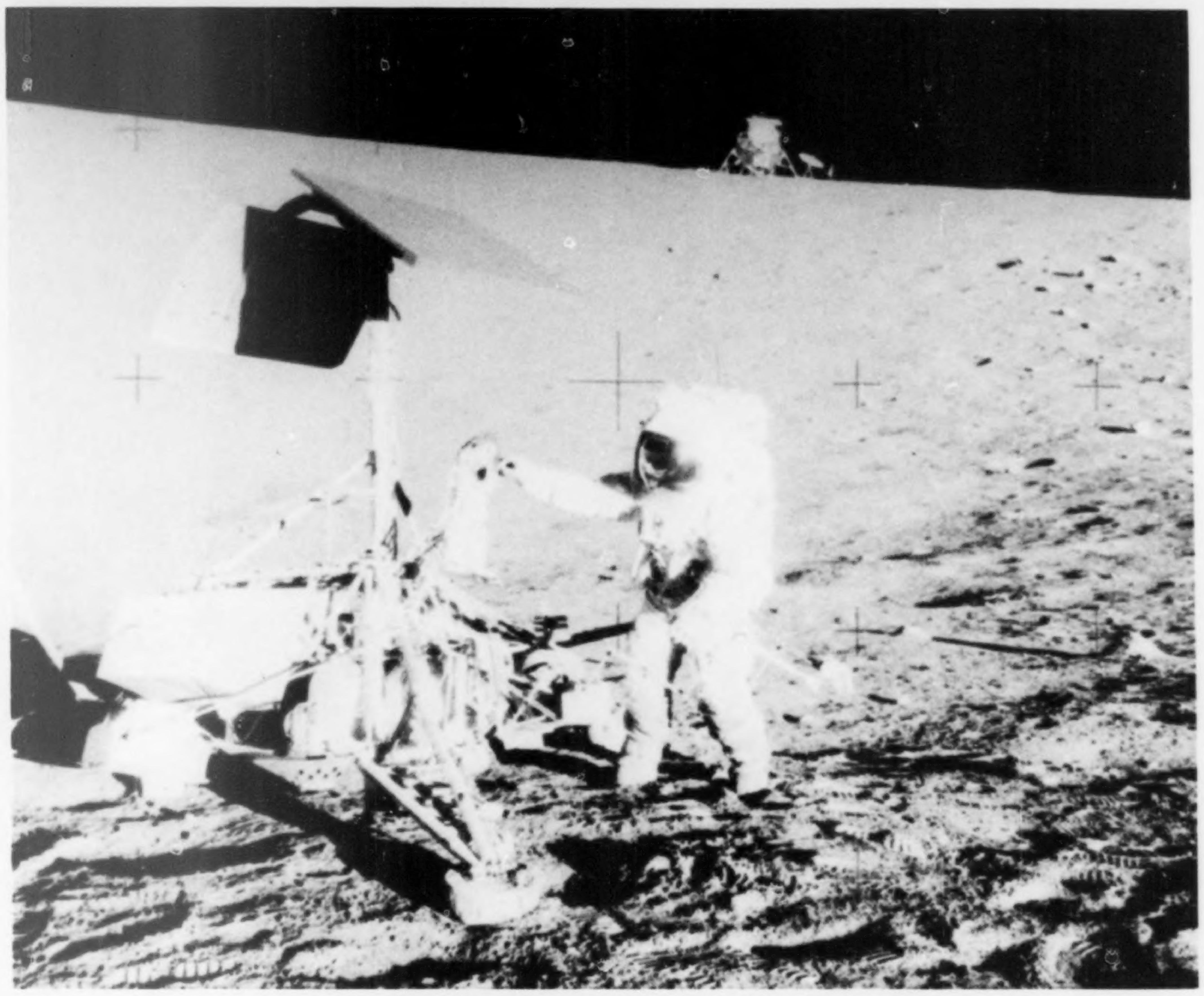
Extraordinary early pilotage: in 1911 Cal Rodgers departs from Long Island, New York, on the first successful transcontinental flight. Flying a Wright Model E-X biplane, he made 69 stops as he crossed the country in 49 days, finally arriving in Pasadena, California. This was less than eight years after the Wright brothers initial short flight at Kitty Hawk.



set sends out electronic impulses, which are reflected back to the set by anything in the way. Used on the ground, radar sets can detect airborne aircraft, and if installed in aircraft, radar can "see" other aircraft as well as the ground. It was this last feature that made airborne radar an invaluable aid, both then and now. When developed and first used by the British, the radar sets enabled the navigator to have an accurate picture of the area that he was flying over. Large cities and towns reflect a lot of energy, and appear as bright spots on the scope. Land reflects less, so is less bright, and water generally reflects the radar energy away from the aircraft, so bodies of water show up as dark areas. Thus, the coastline of a country is easy to spot on radar, as are cities, towns, and airfields. Radar works equally well at night, in bad weather, rain, and snow. Here was the first true all weather navigation aid. Radar equipped aircraft were able to bomb targets that were obscured by weather, and after the war, radar allowed airliners to take off, fly, and land in any kind of weather.

A number of radio aids were developed for navigational use, and while extremely accurate in most cases, these have the disadvantage of being beyond the control of the aircraft navigator. Ground-based radio stations can be turned off or on at will, and in wartime, a ground radio transmitter can help the good guys as well as the bad. Atmospheric irregularities such as sun spots and nighttime conditions can cause radio aids to be unpredictable at times. To overcome these limitations, the work began in earnest for the "perfect" navigational aid shortly after World War II. The answer was the inertial navigation system, now used in virtually all airliners and most military aircraft. This system uses a system of gyros and accelerometers to determine movement in all three planes of motion. This information is covered to distance, which is in turn converted to position. An inertial set requires the operator to "tell it where it is" by inserting the latitude and longitude, and once it becomes fully aligned, it can then give a continual read-out of position, velocity, and distance to go to any desired destination.

Where do things such as this leave today's aerial navigator? Can 'black boxes' and electronic gadgets do the job as well as a person? Well, the navigator (human type) is still an indispensable part of many aircraft crews. Electronics can do fantastic things, but they can (and do) malfunction from time to time. There is no substitute for human judgment and experience, and today's navigator must evaluate all his navigation data, analyze and select the best information, and determine the best course of action. In the U.S. Air Force, navigators are an integral part of bomber, tanker, transport and fighter crews, and have a bewildering array of sophisticated equipment to work with. Some of the techniques used today in this era of supersonic flight are essentially the same as those used by the ancient mariners (celestial, dead reckoning) but have been tailored to fit the times and the aircraft.



The accuracy of modern navigation: the flight of Apollo 12 to the Moon. In the background is the Lunar Module in which the astronauts landed. In the foreground is the unmanned Surveyor III which had soft-landed on the Moon two years earlier. Surveyor III is on the spot where they intended to land, and they were able to put the LM down only 183 meters (600 feet) from it—after a flight of 383,024 kilometers (238,000 miles).

For example, a navigator on a C-130 transport flying from the U.S. to Europe uses celestial as his primary navigational reference. Long range radio aids are used as a back-up, but today's modern way of accomplishing the celestial computations insures accuracy as well as speed. A number of electronic computers are used in the C-130 and other aircraft, but the information supplied by these is dependent on the skill and precision of the navigator. When the information supplied is correct, and all systems operate properly, the navigation gear can provide very precise guidance. The navigator constantly monitors the equipment, and when and if the systems become degraded, he can override the malfunctioning gear.

Navigators are used in a wide variety of aircraft, and one of the more challenging roles is that of the fighter navigator. In single seat fighters the pilot is also the navigator. Imagine travelling at 600 mph only 30 meters (100 feet) above the ground for several hundred kilometers (miles). Fighter aircrews do this routinely, and can deliver their weapons with unerring precision. In a strategic bomber, three of the five officer crew members are navigators, and have the job of guiding the aircraft to the target, directing the weapon delivery and guiding the aircraft back home again, all the while using the various electronic countermeasures systems to protect and defend the aircraft. For the private pilot as well, sophisticated electronic navagational systems, called avionics, are in common use.

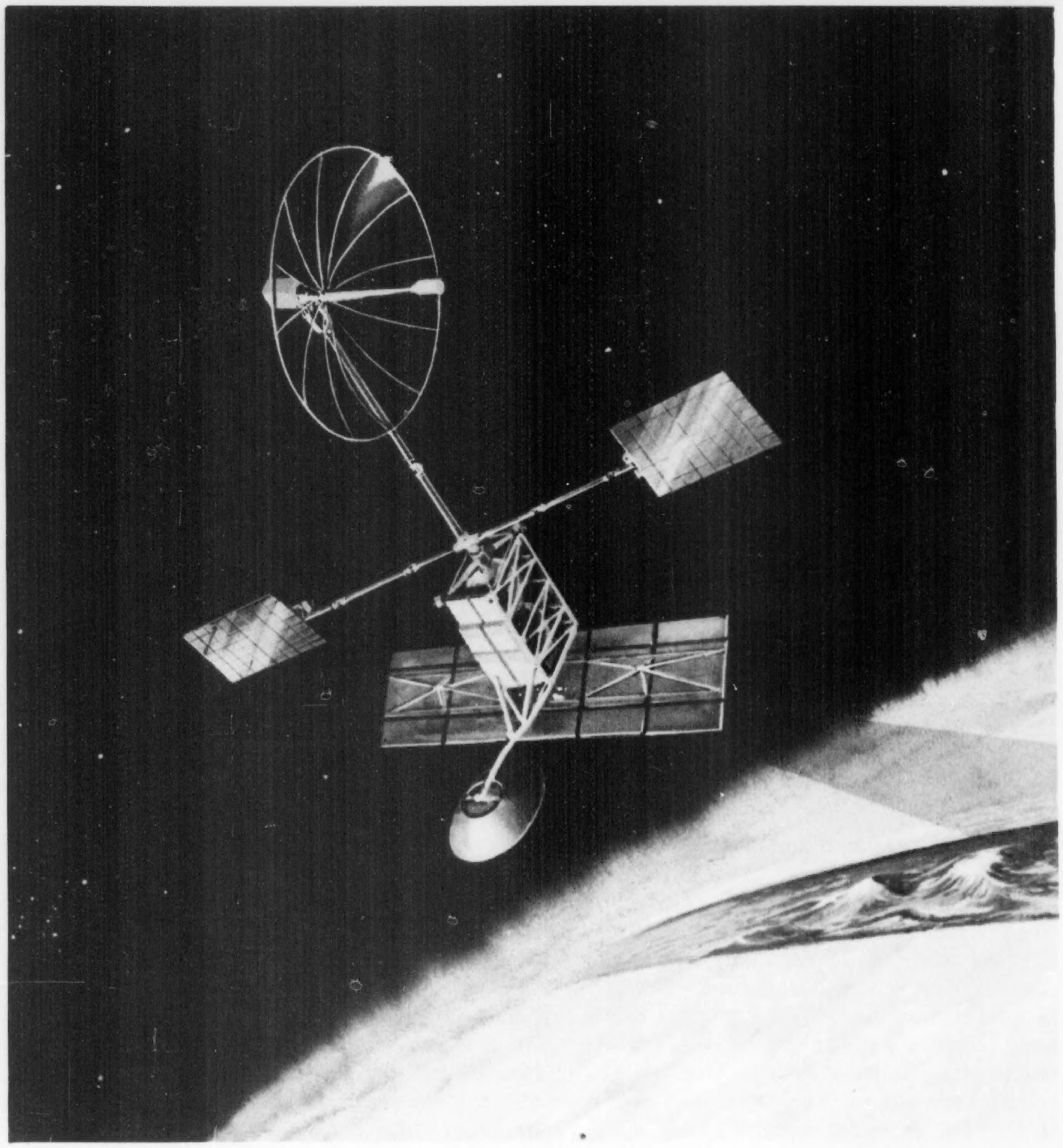
Navigation today is a blend of both art and science, and it is a fascinating combination of procedures and techniques that range from those used by the ancient sailors to those accomplished by modern space age computers. ■

Flight Technology, a sound-strip related to this article, is one of NASM's Flight series. For information about this presentation, and the other 20 dramatic programs in the series, see the back cover.

What's Undercover

Mapping in space

Michael Kobrick
Senior Scientist
Jet Propulsion Laboratory



VOIR spacecraft, in an artist's concept, as it "sweeps away" the Venus clouds.

For a moment put yourself in the shoes of a contemporary planetologist: you study rocks of all sizes, but you are especially interested in how large aggregations of them—planets—form, grow and evolve. You've taken a good look at parts of the planet Earth, walked around on it, hauled chunks of it back home to the lab, and mapped the relationship of this rock to that one. But it's not enough.

You know that neither you nor your colleagues are going to get very far in piecing together the "big picture" of planetary formation and evolution if all you have is one sample planet. NASA has helped you out by sending robot spacecraft to the neighboring planets to probe and measure their surfaces, and has brought you pieces of the Moon to study. In fact, within your lifetime you have seen Mars, Mercury and even the satellites of mighty Jupiter and Saturn come one by one under the gaze of spaceborne cameras, magnetometers, heat and gamma ray sensors, and many even more arcane devices of "remote sensing." But there is still one stubborn holdout, and the frustration bites deep because it's right next door.

Venus. Our sister planet. The radius and mass of Venus are respectively 95% and 82% those of the Earth. It sits a mere 45 million kilometers (27 million miles) closer to the Sun than we do, and with an average density only 5% less than Earth's we conclude that its chemical composition is about the same. Indeed, no other planet is so similar to the Earth in almost all its basic characteristics. But is it really Earth's twin?

When we look at Venus through our mightiest telescopes, we see a brilliant white disk moving through phases like the Moon's, but with absolutely no surface detail. Thanks to the American planetary probes Mariners 5 and 10, Pioneer, and the Russian Venera series, we now know that our telescopes are showing us only the top layer of a thick deck of clouds, and that beneath them lies a crushing atmosphere of almost pure carbon dioxide. The atmospheric pressure at the surface of Venus is almost 100 times that on Earth, the same

Related Flight Series filmstrips: *Rocketry and Space Flight*, and *Great Spacecraft and Their Accomplishments* (see back cover).

as 1006 meters (3300 feet) down in the ocean. The temperature is a balmy 900 degrees F, and to top it off those clouds are made not of water vapor but sulfuric acid. And it rains!

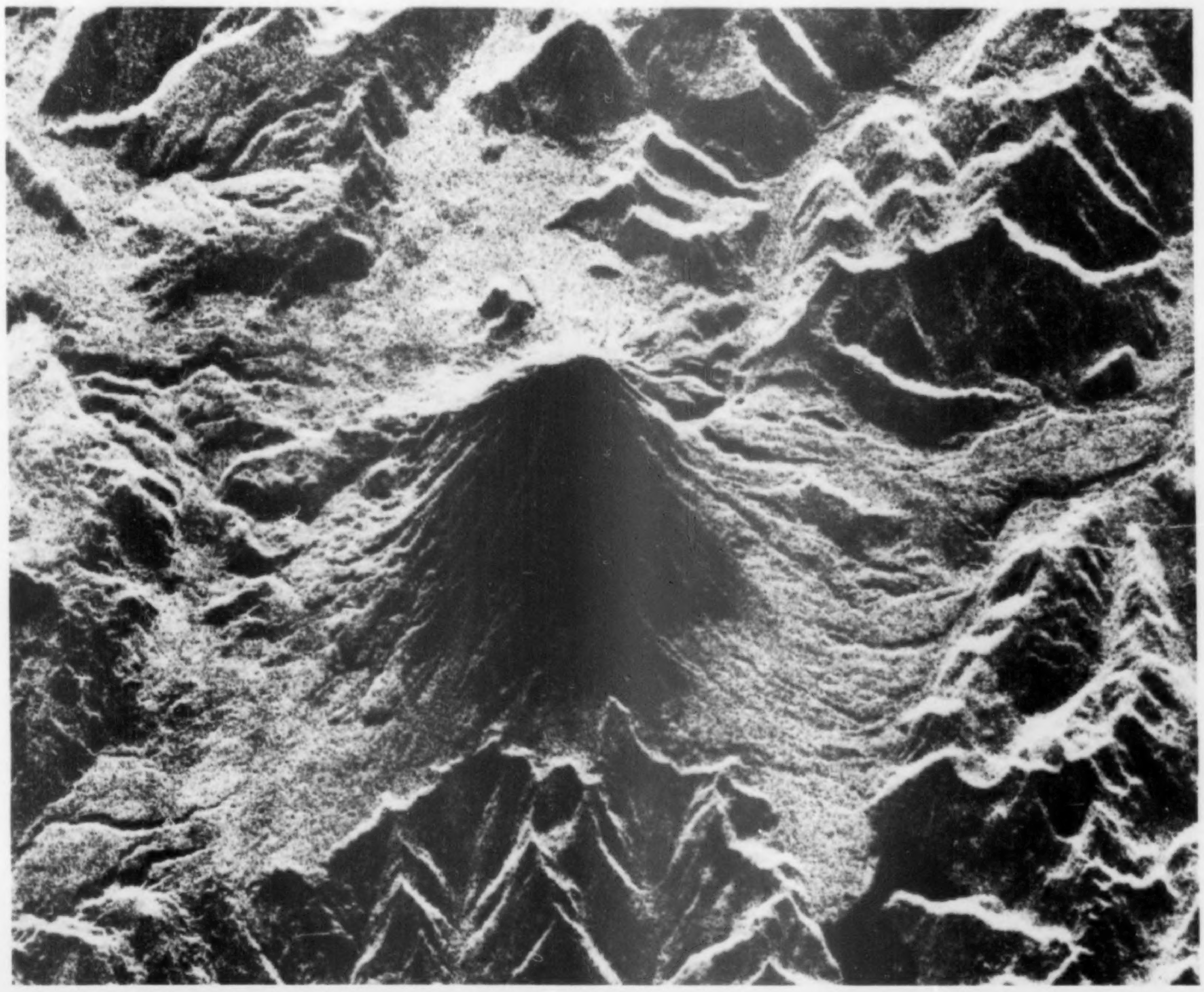
Venus is quite literally a planet under cover. Why should an object so much like the Earth in all the basics have evolved to such a hellishly different state? Here's where the frustration really begins, for with the other terrestrial planets we can fly equipment to take a look and make on-the-spot analyses. But Venus defies all easy approaches. No camera can see through the clouds. The high temperature and pressure mean that landers can survive for at most a few hours, and send back data that applies only to the area immediately surrounding the landing point. The Russian Venera 9 and 10 landers sent one picture each, showing a rocky, seemingly unweathered landscape directly in front of them.

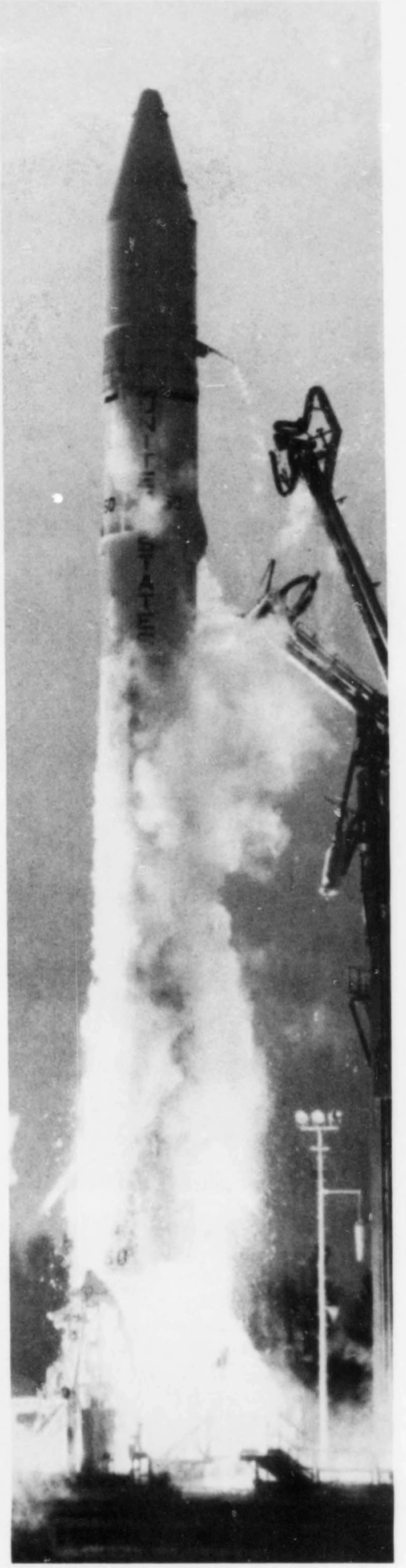
At the other end of the scale, the Pioneer Venus radar altimeter has allowed us to map the topographic highs and lows and construct a computer-generated "picture" of most of the planet. This is like looking at a fuzzy world map of the Earth—such a view would differentiate the major provinces (continents and ocean basins), but would not contain the detail necessary for planetologists to unravel the geologic processes that have formed the surface. Mt. St. Helens, the San Andreas Fault and even the Grand Canyon are all invisible at this scale.

Is there no way to roll back that global murk and systematically map all of Venus with enough detail to permit real geologic analysis? One way is an instrument that has been under development for a number of years that produces photographic-quality images without regard to weather or daylight which is now ready to go. Called Synthetic Aperture Radar, or SAR for short, it has already proven itself as a photogeologic tool during many research flights aboard aircraft and once from an orbiting platform called SEASAT.

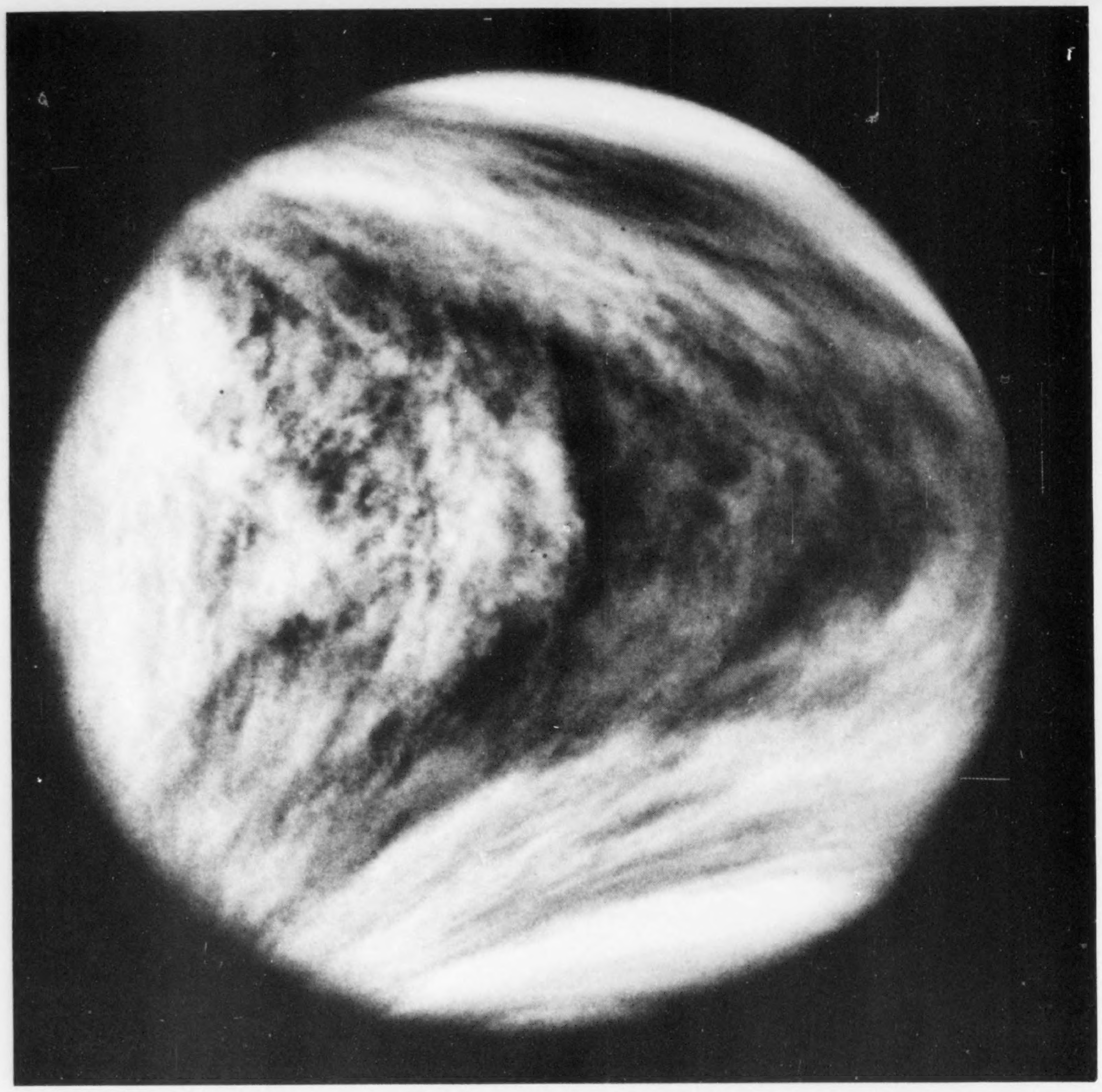
As the name implies, SAR uses microwave (radar) radiation in place of light to form images. These microwaves, with a wavelength of about 23 centimeters, can penetrate the thickest clouds as if they were not there. And since a SAR provides its own illumination by beaming the microwaves toward the surface to begin with, pictures can be taken day or night. The images that SAR produces are almost indistinguishable from photographs except that brightness in the picture is due not to the color of the scene, but to the roughness of the surface compared to the wavelength. A blocky lava flow, for example, scatters the microwaves very well and so appears bright in the image. The resolution (ability to dis-

Seasat radar image of Mt. St. Helens obtained September 1978. The cataclysmic eruption of May 18, 1980, removed about a cubic mile of material from the top of this volcano.

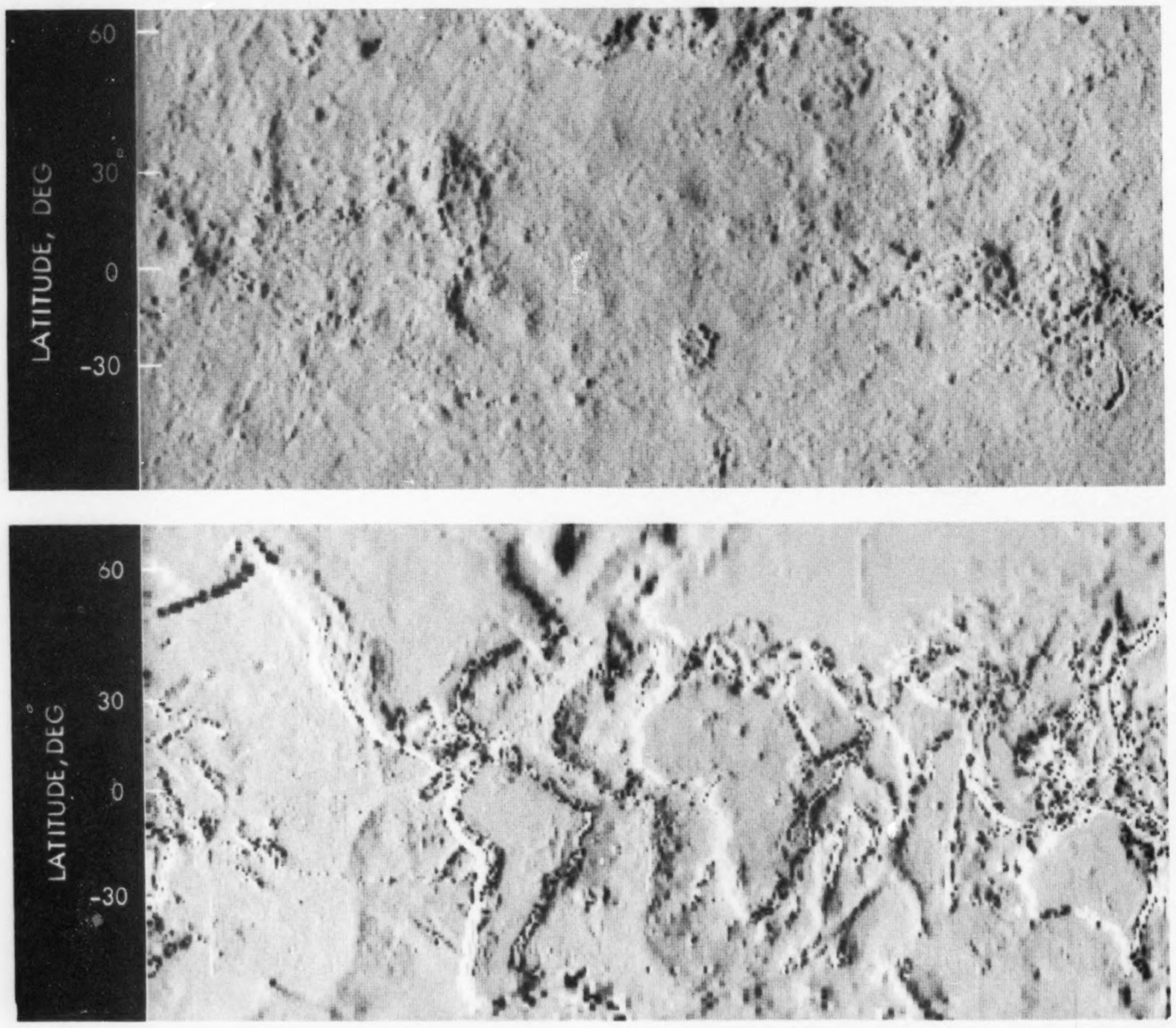




The propulsion needed for space exploration: lift-off of Pioneer Venus from Cape Canaveral on May 20, 1978.



Above, image of Venus taken by the Pioneers Venus orbiter in ultraviolet light. The dark features are ever-changing cloud features; the surface is not visible.



Top, a "picture" of Venus generated by a computer from topographic data returned by Pioneer Venus radar altimeter. The smallest details are about 100 kilometers (62 miles) wide. Below, Earth at the same scale and resolution as the Venus picture. Note the outline of Earth's continents.

cern fine details) of SAR images is frequently better than photographs. So imagine a flash camera that can see through clouds and detect rock sizes—perfect for mapping a planet under cover.

NASA hopes to launch a SAR mission to Venus in 1986. Called VOIR, for Venus Orbiting Imaging Radar, it would produce a map of the planet at the same resolution and scale as the 1971 Mariner 9 map of Mars. This map gave us our first global look at the red planet and revolutionized our ideas of how that body formed and evolved. It seems likely that a comparable map of Venus could profoundly change not only our concept of how Venus got to be the way it is, but by extension, the Earth itself.

In addition to the SAR imager and a radar altimeter to measure the planet's topography, six other experiments will probe beneath the surface (by measuring deviations in the gravity field) and study the detailed structure of the atmosphere and ionosphere. By attaining this overall view scientists hope to reach a better understanding of the complex interactions between the solid planet, atmosphere and near-space environment (solar wind and magnetic fields) that control the evolution of a terrestrial planet.

Some of the atmospheric studies have obvious applications to the Earth. For example, the high temperature on Venus is due not to its proximity to the Sun, but to the high carbon dioxide content of the atmosphere. This gas has the property of allowing incoming solar untraviolet light to pass through freely and warm the surface, but blocks the outgoing, cooling infrared radiation. Called the Greenhouse Effect, this process is not very important in warming the Earth because atmospheric carbon dioxide exists in very small amounts. But, according to some scientists, for the past century or so one of the by-products of burgeoning human technology has been a slow but detectable increase in the con-

Aerospace Convention

The 14th Annual National Congress on Aerospace Education, sponsored by the Federal Aviation Administration, NASA, and the Civil Air Patrol, will be held April 2-4 at the El Tropicano Hotel, San Antonio, TX. For information and registration forms, contact National Congress on Aerospace Education, HQ CAP/EDF, Maxwell AFB, AL 36112. (205) 293-5371.

centration of this gas. A better understanding of the long term effects of atmospheric change such as carbon dioxide increase, ozone depletion and even acid rain is one of the ultimate results of studying Venus.

Less obvious but just as important is the applicability of probing the surface and solid body of the planet, the primary mission of VOIR. But recent dramatic volcanic eruptions and earthquakes have drawn attention to the substantial impact plate tectonics can have on human life. The term plate tectonics refers to the sliding around of great land masses, or plates, on the soft, semi-molten rock underneath. Collisions at the edges of these plates are responsible for the growth of mountain chains, oceanic trenches, volcanoes and the occasional devastating earthquakes that are a fact of life in some areas of the world. So far Earth is the only planet we know where plate tectonics exists. The Moon, Mars and Mercury seem to have relatively rigid outer layers that have remained more or less fixed throughout their histories. But these bodies are substantially smaller than the Earth, and we might therefore expect their interiors to be less complicated and dynamic. Venus, almost Earth-sized, remains hidden.

If our sister planet undergoes the same sort of violent upheavals as Earth, we obviously have much to learn from her. If she does not (as the skimpy evidence we already have seems to suggest) we might learn even more, for again we'll be faced with another enigma. Why should two planets of almost the same size and composition be so different in major ways? Are the small disparities in mass and chemistry that important? What are the implications for the future evolution of the Earth?

Technology has given us the power to change our environment profoundly. It has not given us the wisdom to manage that technology correctly, nor even the information necessary to understand the long term effects of our tinkering. What we can do now, however, is observe the laboratory specimens nature has thoughtfully provided, the eight other planets and scores of smaller bodies. ■

Readings

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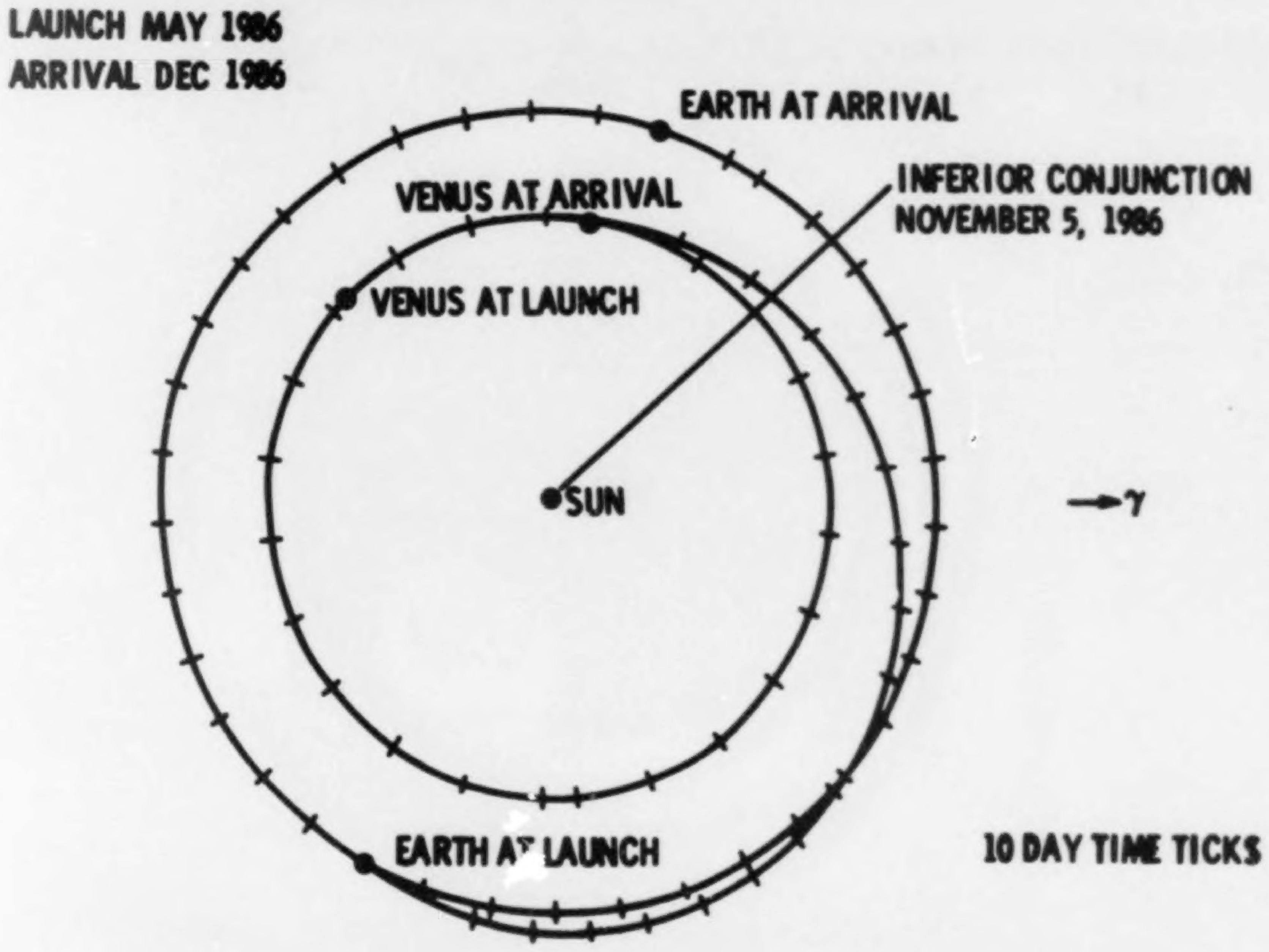
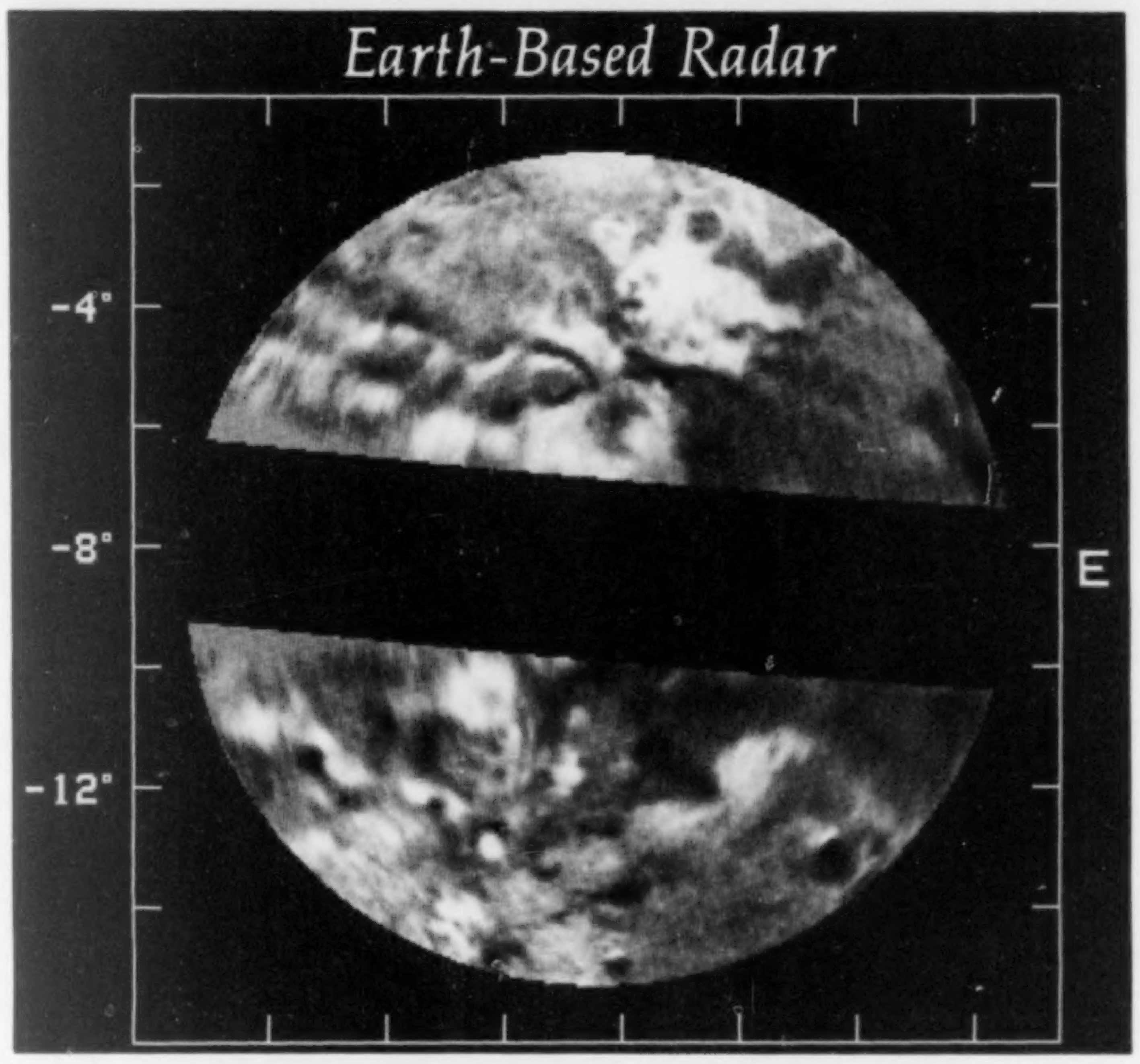
Alien Eyes, M. Kobrick, Astronomy, January, 1980, p. 6.

Side-Looking Airborne Radar, H. Jensen, L.C. Graham, L.J. Porcello and E.N. Lioth, Scientific American, October, 1977, p. 84.

Physical Properties of the Planets and Satellites from Radar Observations, G.H. Pettengill, Annual Reviews of Astronomy and Astrophysics, 1978, p. 265.



Trajectory and schedule for the proposed VOIR mission.



An Earth-based radar image of Venus obtained by NASA's Goldstone tracking station in California. The area of Venus shown is about 1250 kilometers (777 miles) in diameter. The black band is an area for which radar data could not be reconstructed.

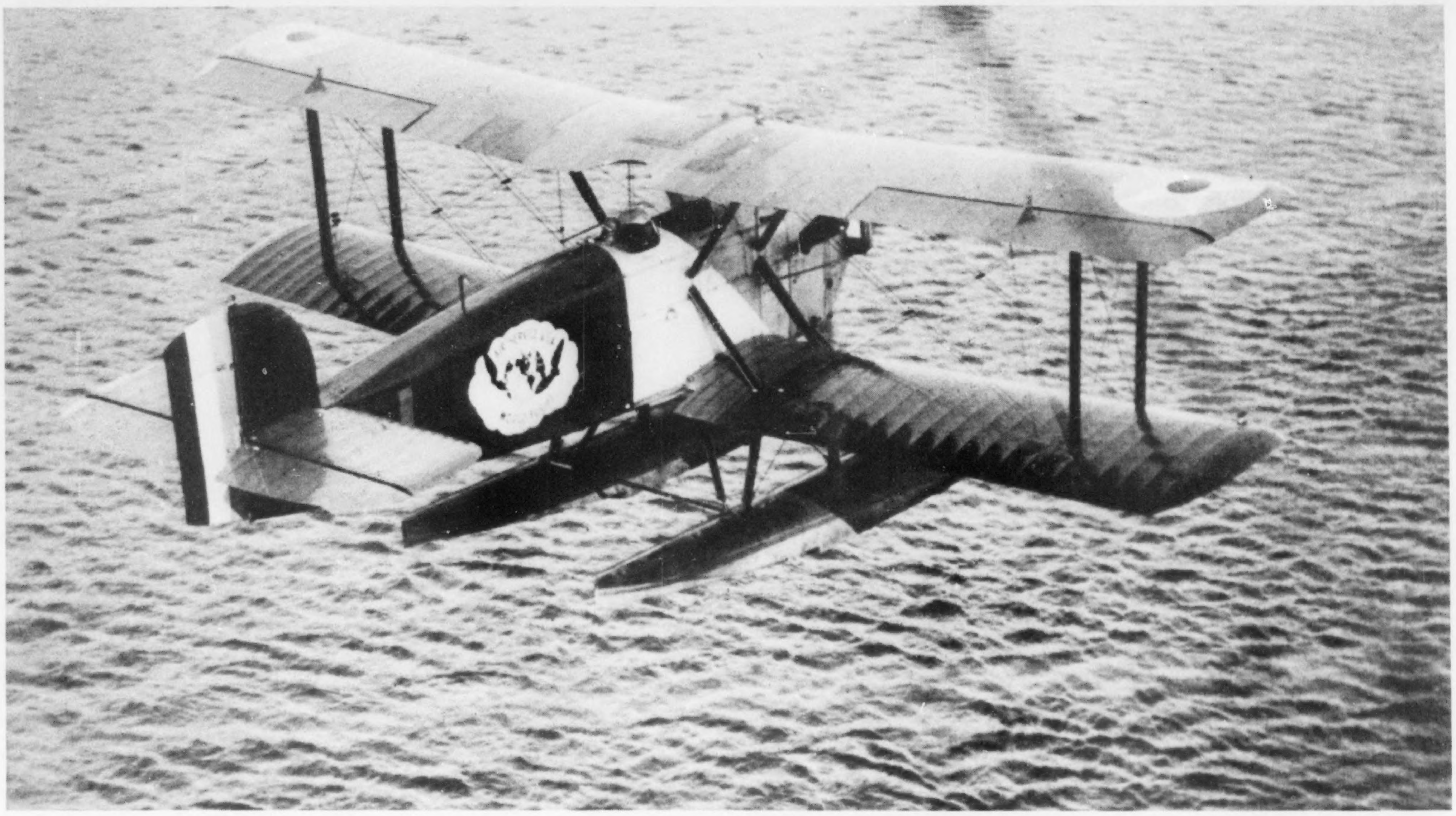
It was only in 1962 that a radar signal from Earth was first successfully detected after reflecting from Venus. From this humble beginning, Earth-based radars have contributed mightily to our knowledge of the Venus surface.

Because Venus is shadowed in thick haze and clouds, even so simple a thing as its rate of rotation remained a mystery . . . until radar. And what a surprise! Not only did the planet rotate very slowly—once every 243 days, but it also rotated retrograde or backwards compared to all the other planets.

Earth-based radar data of Venus can be computer processed and displayed as maps of elevations or as "images" of surface features. These images are not as easy to interpret as those produced by Synthetic Aperture Radars (SAR). Still, some features such as huge craters or long, deep valleys show clearly and are difficult to misconstrue.

The study of Venus with Earth-based radars does have its limitations. Only surface features larger than about three kilometers can be detected and then only when Venus is closest to Earth, the most favorable time for observation. At these times, unfortunately, it is always the same face of Venus that presents itself for study.

Robert W. Wolfe
Geologist, NASM



The Chicago, *one of the four Douglas Cruisers, during an over-water leg of its historic transglobal flight in 1924.*

Douglas World Cruisers

The first around-the-world flight

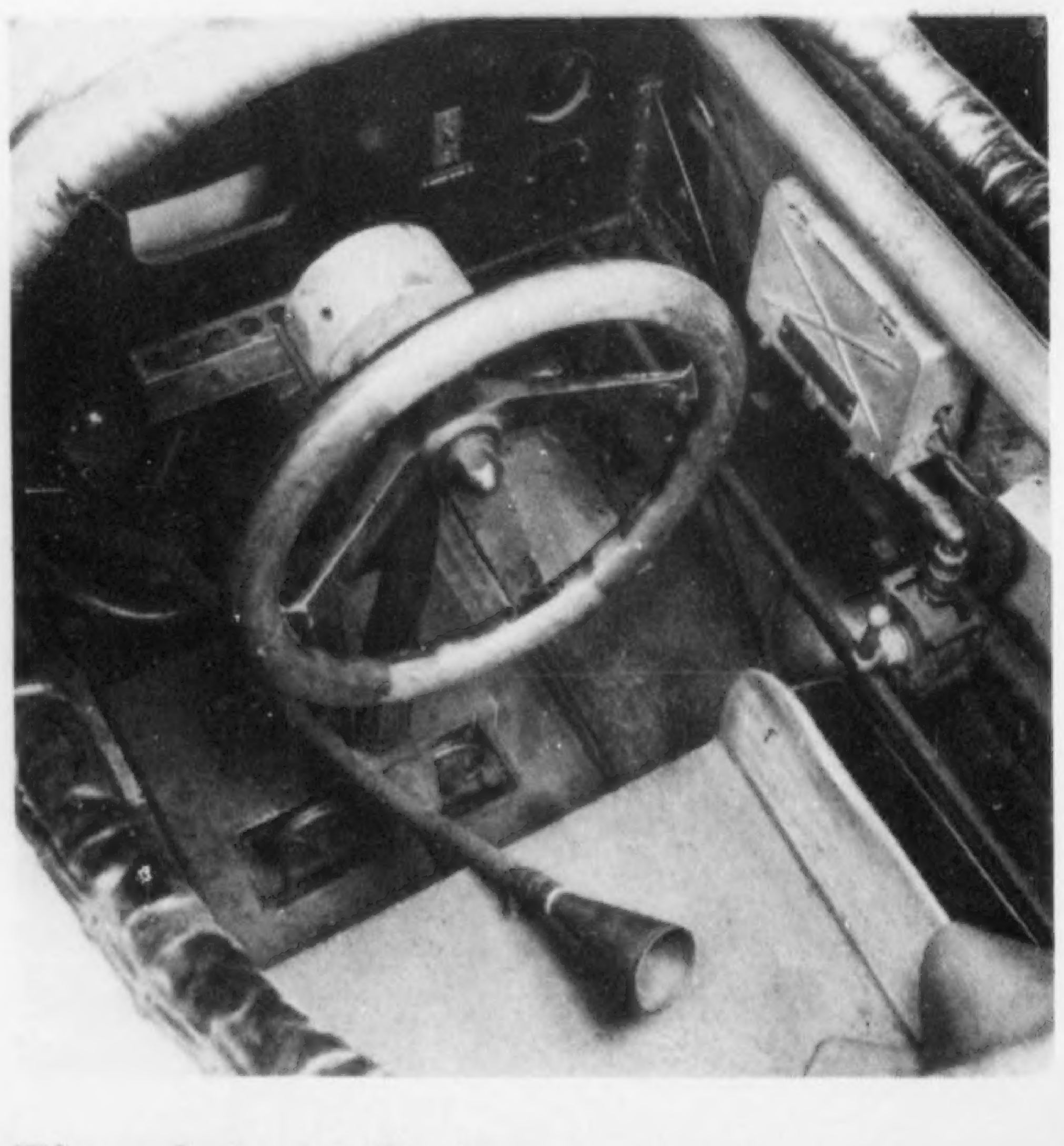
Claudia M. Oakes
Assistant Curator
Department of Aeronautics, NASM

In 1924, powered, manned flight had just passed its 20th birthday. In World War I, the airplane had proven itself able to play a vital military role, and it was currently providing entertainment in barnstorming, air racing, and speed and altitude record flights. To prove somehow that the airplane was a valuable and viable method of transportation and could therefore have a great impact on the world's future, the U.S. Army Air Service decided to attempt a round-the-world flight. Although five other nations tried, the U.S. was the first to succeed on April 6 to September 28, 1924.

The Douglas Aircraft Company was commissioned by the Army Air Service to build an aircraft for the flight. The result was an open-cockpit, two-place biplane of tubular steel and wood framework with fabric covering. It was powered by a twelve-cylinder water-cooled Liberty engine of 420 horsepower.

After the prototype was tested, four more Douglas Cruisers were built, numbered 1, 2, 3, and 4, and named after four U.S. cities—*Seattle, Chicago, Boston,* and *New Orleans*—as part of a campaign to stir public interest in the flight.

The four aircraft had no radios or weather forecasting equipment, and their only instruments were a compass, an altimeter, and a turn-and-bank indicator. They were rigged for either wheels or pontoons, and they would alternate them as conditions required. Their ceiling was 3048/2134 meters (10,000/7,000 feet), depending on whether they used the wheels or pontoons, and the limited ceiling meant that instead of flying over clouds and fog they would frequently have to fly under them, even if that called for flying almost at tree-top level. Navigation, of course, was mainly a matter of using the compass and the eyes of the pilot and navigator in each airplane.



The cockpit of a Cruiser.

That projected flight of some 43,452 kilometers (27,000 miles) in 1924 appeared almost as challenging as did a journey to the Moon in 1960.

The four pilots appointed for the flight by the Air Service were: *Seattle*—Maj. Frederick L. Martin (pilot and flight commander) and Sgt. Alva I. Harvey; *Chicago*—Lt. Lowell H. Smith (pilot), and Lt. Leslie Arnold; *Boston*—Lt. Leigh Wade (pilot) and Lt. Henry H. Ogden; *New Orleans*—Lt. Erik H. Nelson (pilot) and Lt. Jack Harding.

Director of the flight was Maj. Gen. Mason M. Patrick, Chief of the Air Service. He headed a logistics and planning operation unparalleled for that time.

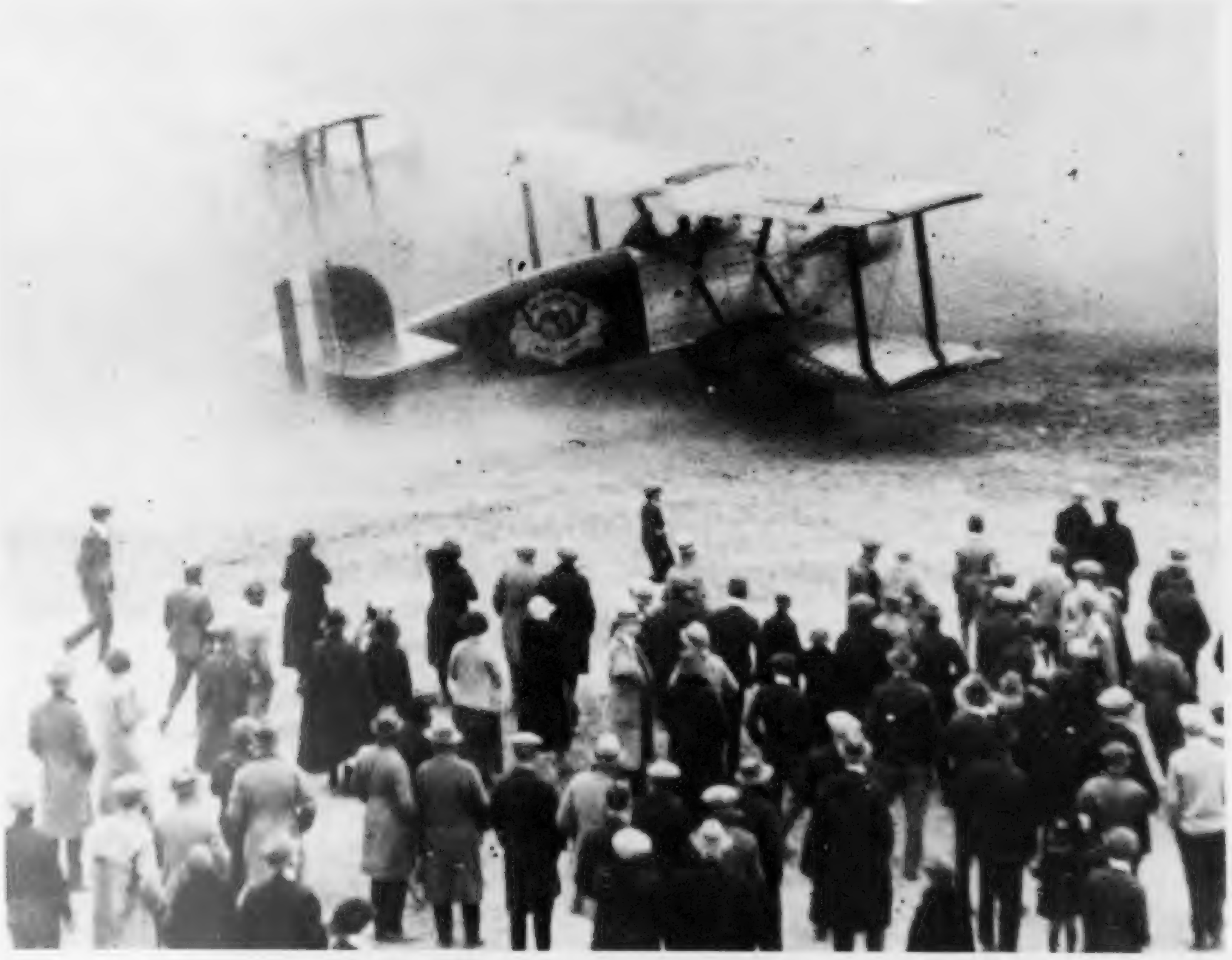
Under the supervision of Lt. St. Clair Streett, mechanics and technicians were sent to bases along the route the aircraft would take. Special crates of spare engines, parts, and tools were readied for shipment. At several bases throughout the route, the planes would use facilities of the Royal Air Force. Also the U.S. Navy would stand by to assist on the over-water legs of the trip.

On April 6, 1924, the flight took off from Seattle and immediately encountered bad weather. The *Seattle*, which had been delayed by a forced landing caused by engine trouble, was trying to catch up to the others when the weather forced it off course. It crashed near Chignik, AK, fortunately without injury to the crew.

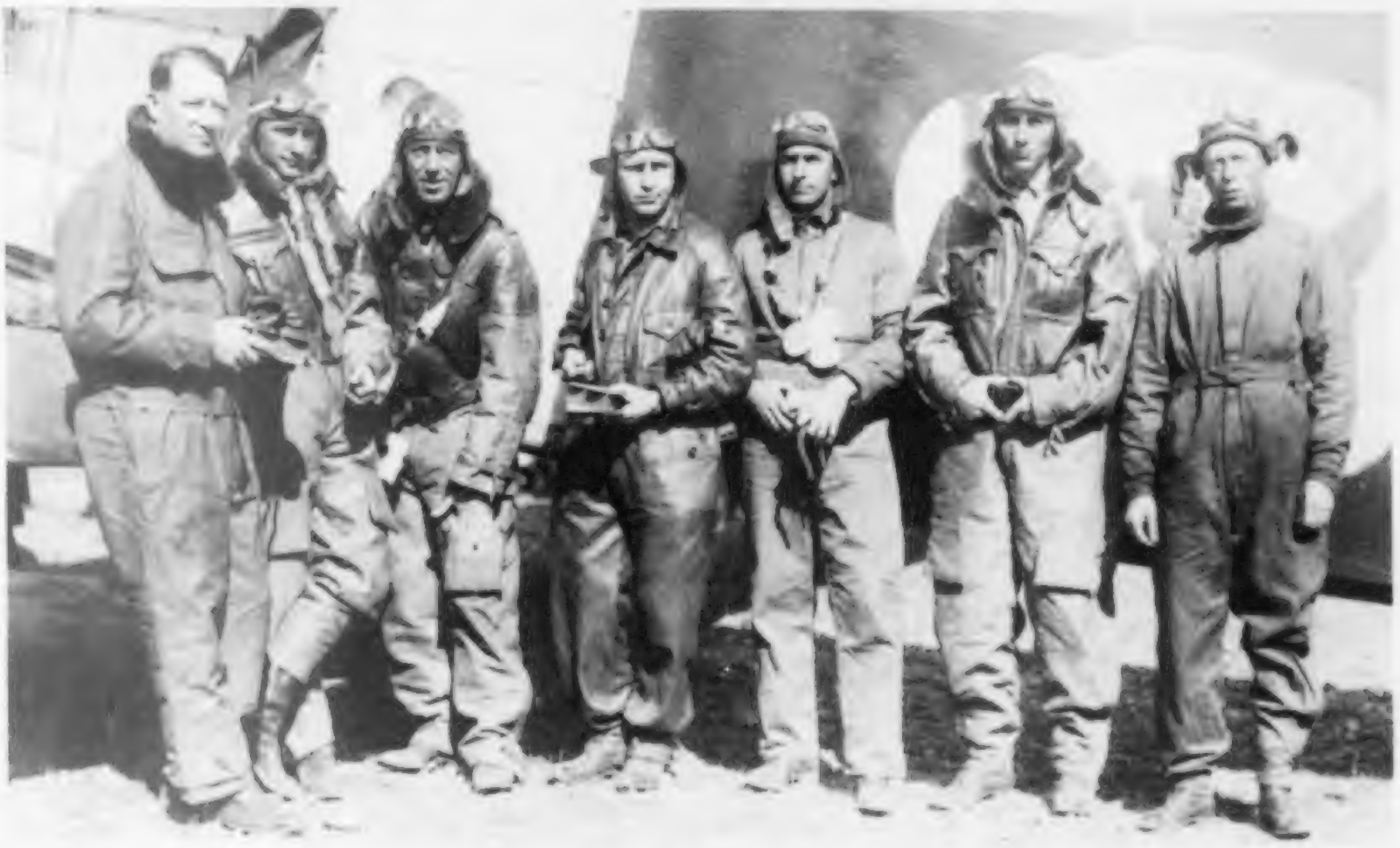
The other three airplanes continued without mishap, however, across the Pacific to Japan, China, Indo-China, Siam, Burma, India, Persia, Asia Minor, the Balkans, and France. From Strasbourg, they were escorted to Paris by the French Air Force, and there they received a tumultuous welcome from cheering crowds on Bastille Day. The next day they left Paris and landed in London.

Disaster again occurred between the Orkney and Faroe Islands, when the *Boston* suddenly lost oil pressure and had to land at sea. Although the landing was successful, the *Boston* was damaged beyond repair during an attempt to hoist it on board a Navy ship. At Pictou, Nova Scotia, the prototype aircraft arrived to join the remaining two and became the *Boston II*. From there the planes flew on a triumphal journey across the United States, arriving in Seattle on September 28, having accomplished the 44,341 kilometers (27,533-mile) flight in 175 days, or 371 hours 11 minutes flying time, with an average speed of 70 miles per hour.

Two of the World Cruisers still survive. The *New Orleans* (#4) is in the Air Force Museum at Dayton, Ohio. The *Chicago* (#2) is in the collection of the Smithsonian's National Air and Space Museum; it has been restored and is on exhibit in the Pioneers of Flight gallery. ■



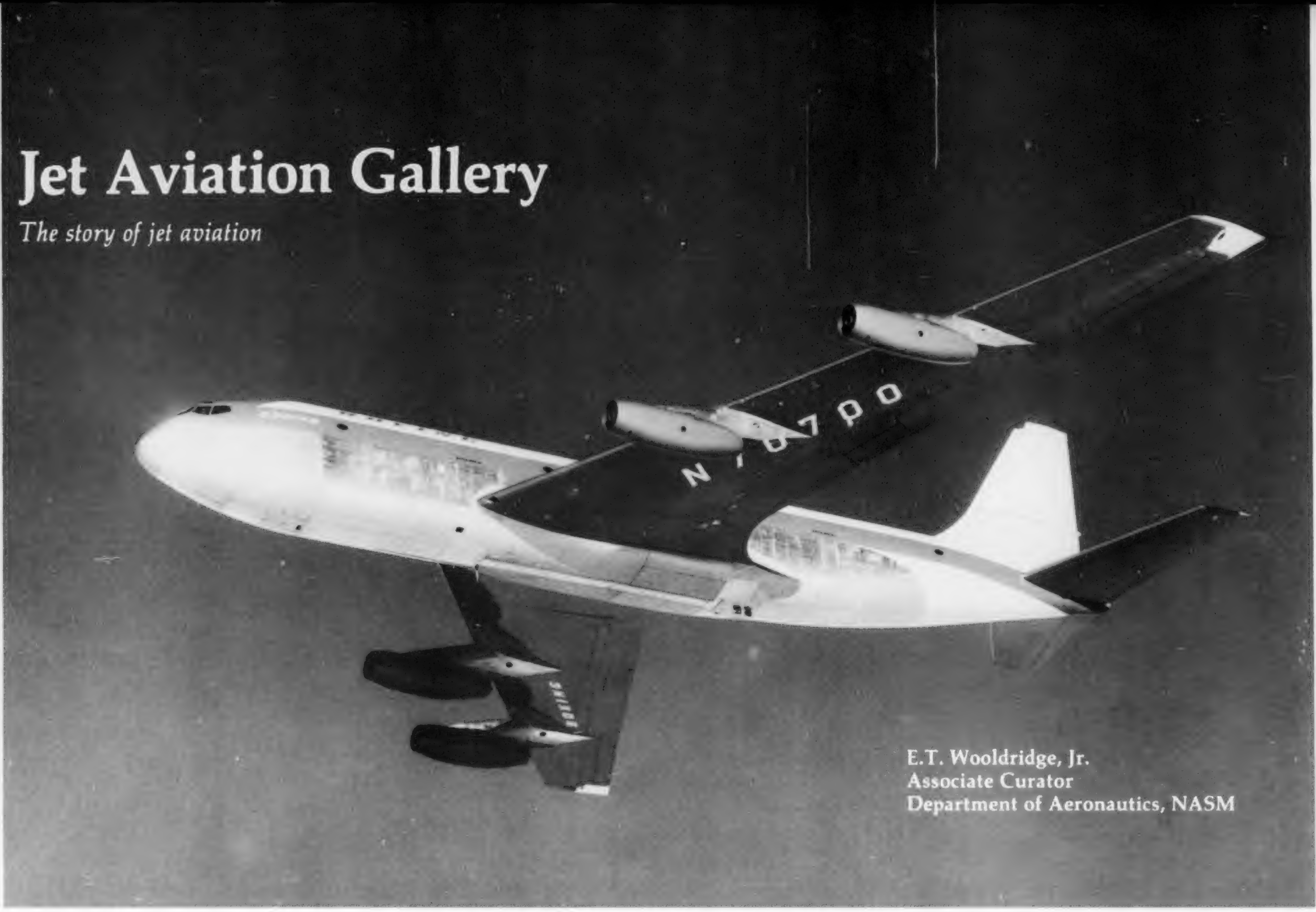
Above, takeoff from Clover Field at Seattle, Washington, April 6, 1924. Below, several members of the Douglas World Cruiser crews pose with an unidentified pilot during an en-route stop. Left to right: the unidentified pilot; Lt. Lowell H. Smith (Chicago); *Maj. Frederick L. Martin* (Seattle); *Lt. Leigh Wade* (Boston); *Lt. Erik H. Nelson* (New Orleans); *Sgt. Alva L. Harvey* (Seattle); *Lt. Henry H. Ogden* (Boston).



The four cruisers anchored in the harbor at Sitka, Alaska.

Jet Aviation Gallery

The story of jet aviation



E.T. Wooldridge, Jr.
Associate Curator
Department of Aeronautics, NASM

The Boeing 707 (367-80), the prototype for the first U.S. jet transport. Known as the Dash Eighty, this aircraft was designed to demonstrate the feasibility of a jet-powered military tanker transport as well as a commercial airliner. The Dash Eighty flew for the first time on July 15, 1954, and was used as a flight test aircraft for 18 years. The Dash Eighty will be the subject of an exhibit in NASM's new Jet Aviation Gallery.

The first turbojet-powered aircraft flew on August 27, 1939, and the world then entered the jet age.

With that first flight of the Heinkel He 178 and the operational use of the jet aircraft in combat a few years later, Germany led the way to a revolution in aircraft designs. Between the two extremes of the simple He 178 and today's complex Lockheed SR-71, there have been aircraft of every configuration. Many endured and enjoyed lasting fame; some were designed only to prove an aerodynamic theory; while others embodied designs and concepts ahead of their time.

Many of these designs may be viewed in a new gallery devoted to the history of jet aviation, scheduled to open in the Summer of 1981. The exhibit is a tribute to the pioneers of the jet age and their achievements. It highlights some of the accomplishments and unusual feats of the first four decades of jet aviation. The exhibit will afford a unique opportunity to savour the atmosphere of the jet age and to study the technical developments that have produced the advanced aircraft of today.

Two feature attractions of the new gallery are the Lockheed XP-80 and the Messerschmitt Me 262. The "spinach green" XP-80, first U.S. operational jet fighter, stands wing tip to wing tip with the world's first operational jet fighter, the German Me 262, resplendent in its two-tone green camouflage and colorful Luftwaffe squadron markings. Standing nearby, in marked contrast with its dark blue finish, is the world's first operational shipboard jet fighter, the McDonnell FH-1 Phantom. Completing the aircraft display is the Bede BD-5J, a tiny general aviation aircraft weighing in at 408 kilograms (900 pounds), powered by a 200-pound thrust engine.

Complementing the aircraft display are a variety of foreign and U.S. gas turbine engines, ranging from the diminutive 700-pound thrust Williams WR19, the world's smallest turbofan engine, to the 53,000-pound thrust Pratt and Whitney JT9D turbofan engine from a Boeing 747. The immense size of this engine can be appreciated as the visitor enters the gallery through the eight-foot wide nacelle from a JT9D engine.

The impact of computer technology is dramatically demonstrated by a simulated instrument approach to London on the British Aerospace Advanced Flight Deck, a commercial jetliner cockpit in which information required for navigation and control of the aircraft is presented to the pilot on an array of television sets. Visitors interested in aircraft design will enjoy designing a jet transport or fighter using a sophisticated computer graphics system. Computer operated quizzes may be taken by those interested in testing their knowledge of famous jet aircraft, aviation personalities and events, or the technical aspects of engine and aircraft design and operation.

Providing an impressive and imposing backdrop for the exhibits in the gallery will be a large, 6 meter x 23 meter (20'x75') mural featuring 25 significant aircraft of the jet age. Painted by the renowned aviation artist Keith Ferris, whose B-17 mural in the Museum's World War II gallery has received considerable acclaim, the mural will commemorate those pioneers of the jet age whose vision, genius, and hard work created the machines and established the milestones celebrated in NASM's new Jet Aviation Gallery. ■

The XP-80, which will be displayed in the Gallery, was the prototype of the P-80 Shooting Star, the first operational turbojet fighter to undergo full production in the U.S. Known affectionately as "Lulu-Belle," the aircraft was built in the record time of 143 days, and it first flew on January 8, 1944.

The first flight of the McDonnell XFD-1 Phantom in January 1945 marked the entry of the U.S. Navy into the jet age. On July 21, 1946, the FH-1, as the production version was called, became the first U.S. pure jet aircraft to take off from and land on an aircraft carrier. It subsequently became the first jet fighter in operational service with both the U.S. Navy and U.S. Marine Corps. NASM's FH-1 served with Marine Fighter Squadron 122 (VMF-122), completing its service in April 1954.

The Bede BD-5J, here being flown by author Richard Bach of Jonathan Livingston Seagull fame, is the world's smallest manned jet. The all-metal BD-5J in NASM's Jet Aviation Gallery features a reclining seat, spring-loaded inlet ducts, a wrist-activated side control stick, manually-retractable landing gear, and a "stabilator," or combination stabilizer and elevator. The BD-5J weighs just under 1000 pounds fully loaded, and is powered by an engine which weighs just 80 pounds and produces 200 pounds of thrust. Maximum speed of aircraft is about 276 mph at sea level.

The Messerschmitt Me 262, nicknamed Schwalbe, *or Swallow, was the world's first operational jet fighter. It surpassed the performance of every other World War II fighter, and its jet engines, swept wing and extremely high speed set the pattern for future aircraft design. More than 6000 man-hours were spent in restoring NASM's Me 262, which will also appear in the new Jet Aviation Gallery.*

Related Flight series filmstrip: *Air Transportation* (see back cover).

DC-8
Super 63

Can you create a name for an airline flight?

Two Tickets to Boston on the Flying Pilgrim

Naming airline flights

A student activity on air transportation

Melvin B. Zisfein
Deputy Director, NASM

For many years, the railroads have carried on a wonderful tradition of giving colorful names to their more important or glamorous runs. For example, the Amtrak express train that leaves New York City every afternoon bound for Chicago, is listed in the timetable as the *Broadway Limited,* no matter which locomotives and cars make up that day's train. In contrast, few airlines have named individual flights during the 67 years of airline transportation in the U.S. One of the few was the *Redstone Rocket,* a Capital Airlines flight between Washington, D.C., and Huntsville, Alabama, during the 1950s; it was named for Redstone Arsenal in Huntsville, a major rocket development agency.

Naming individual *airplanes* is a common practice, but few people notice the name painted on an airliner (such as *Mainliner Detroit* or *City of Portland*) because passengers generally emerge from the airport terminal and walk through a closed corridor directly into the airplane. Naming the *flights,* not the airplane, is what is suggested here, just as railroads named a particular train, and not necessarily its locomotive. But before naming airline flights, let's review how the railroads name their trains.

The railroad tradition of naming important trains sometimes draws on the history or geography of the regions they serve. For example, the current Boston to Washington Amtrak timetable lists *The Minute Man, The Valley Forge, The William Penn, The Yankee Clipper,* and *The Beacon Hill,* to name a few.

Some train names were chosen to suggest abstract concepts such as modernism, progress, and luxury. For example, one of the most famous U.S. passenger trains was the New York Central Railroad's *Twentieth Century Limited* which, during the period 1902-1971, left New York City every day and arrived in Chicago as soon as 16 hours later. At one time, riding the *Century* was the most glamorous way to go from New York to Chicago.

FORT PITT
LIMITED

The railroads used to have colorful names for their important routes.

Other train names salute a city or state, such as the *San Francisco Zephyr,* the *Garden State* (New Jersey), and *The Pennsylvanian.* Some train names highlight important features of their schedules, such as the *Night Owl,* an overnight sleeper train between Washington and Boston. Similarly, the Wabash Line's *Midnight* traveled between St. Louis and Chicago, beginning its journey near—of course—midnight.

Another source of train names has been the names or nicknames of famous people. The *Empire Builder* ran between Chicago and Seattle over the route of the Great Northern Railroad. It was named after Jim Hill, known as "The Empire Builder," who led the development of that railroad and the surrounding region. The *James Whitcomb Riley,* which ran from Chicago to Cincinnati, ran through Indiana and was named for the great poet from that state. Another train honoring a famous person was the New York Central's *Commodore Vanderbilt,* named after one of its most prominent presidents.

We have seen that interesting and exciting train names can be derived from many sources. Why don't we name airline flights as well?

Student activity:
This activity which asks students to create names for real airline flights provides an opportunity to investigate geography, history, folklore, etc.

1. Pick an airline.
2. Get a general timetable of your airline and route map.
3. Pick a route, such as Detroit, MI, to Houston, TX. As of this issue, Delta's non-stop Flight #521 flies from Detroit to Houston. On the return trip Delta's non-stop Flight #818 flies from Houston to Detroit.
4. Decide on what basis these flights should be named; what criteria should we use. For the northern end we could celebrate Detroit's position as an automobile center, or as a center of modern rock music. Alternatively, by consulting some history or folklore books we might name the flight after a distinguished Detroiter or resident of Michigan. For the southern end of our route we could celebrate Houston's position as a manned spaceflight center, or as a petroleum center. The criteria cited so far don't begin to exhaust all of the possibilities. We could also use city or state flowers, animals, mottoes, famous local events, city or state nicknames, etc.

Name the flights that you have selected. Could one of my Detroit-Houston flights be *The Motor City Special,* and another *The Lone Star Rocket?* Use your imagination and you'll probably create far better names than these. ■

PISTOL PACKIN' MAMA

During World War II, members of the Women Airforce Service Pilots ferried four-engine heavy bombers, such as the Boeing B-17.

Women Airforce Service Pilots

Claudia M. Oakes

In 1941, Jacqueline Cochran, who had gained fame as an outstanding pilot in the 1930s, was assigned as a civilian consultant to the staff of the Commanding Officer of the U.S. Army Force Ferry Command to study the possible use of women pilots in that field.

Although a positive recommendation was issued, it was not accepted because at that time there were many male pilots and no provision had been made for the training of women pilots.

The British Air Commission was more inclined toward the idea, and in 1942, Gen. H.H. Arnold instructed Cochran to recruit and take to England a group of women to perform airplane ferrying duties. These 25 women served for 18 months with the British Air Transport Auxiliary.

In September 1942, a women pilot program was organized in the United States. It was organized in two parts: 1) the organization of a squadron of experienced women pilots to do ferrying in the Air Transport Command; 2) the initiation of a training program for women pilots. Nancy Harkness Love headed the ferrying group, known as WAFS (Women's Auxiliary Ferrying Squadron), and Jacqueline Cochran returned from England to take charge of the training program. Initially, 30 women went directly into the WAFS, while the training program was set up for 500.

The stated objectives were:

1) to see if women could serve as military pilots and if so, to form the nucleus of an organization that could be rapidly expanded;

2) to release male pilots for combat;

3) to decrease the Air Forces' total demands on the manpower pool.

The Municipal Airport at Houston, TX, was first selected for training, but there were no barracks facilities and the aircraft available were civilian surplus or obsolete types. In February 1943 the training program was moved to Avenger Field in Sweetwater, TX, where the flying equipment available consisted of PT-17s, PT-19s, BT-13s, BT-15s, AT-6s, AT-17s, UC-43s, UC-78s, and UC-81s.

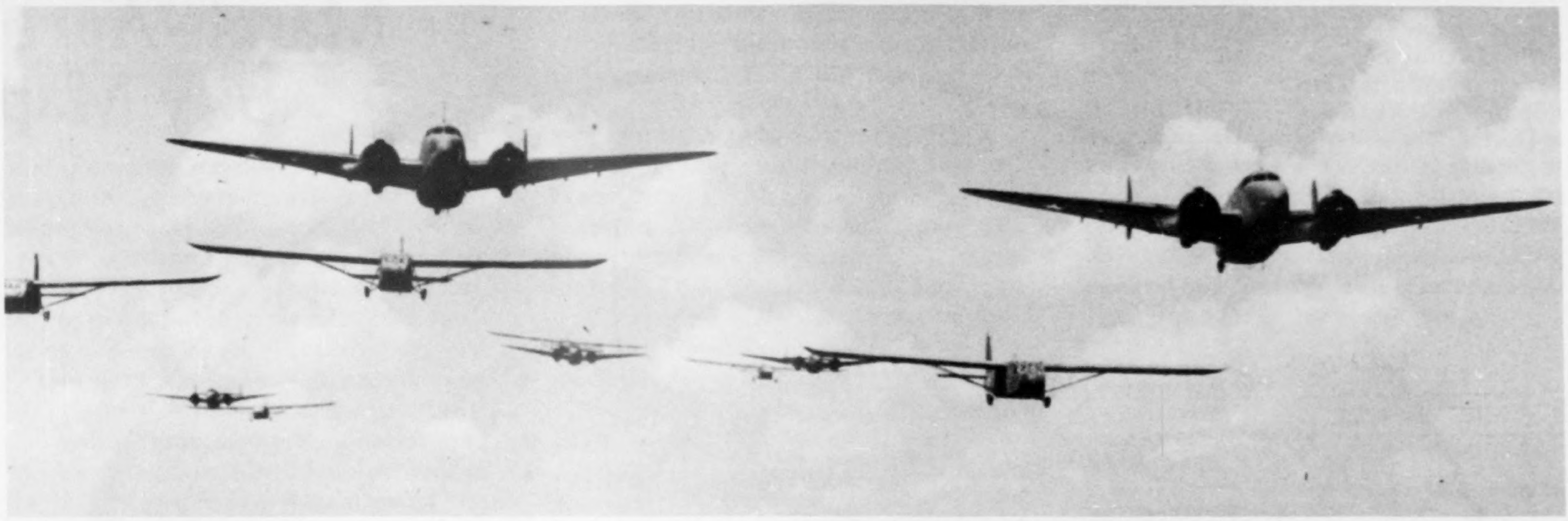
The curriculum covered military training, including military customs, Articles of War, drill and ceremony, safeguarding military information, ground school courses such as physics, mathematics, navigation, flight principles and instrument flying, and primary through advanced flight training. As far as possible, the women were required to follow the same schedules as male flight cadets.

On August 5, 1943, the trainees and the WAFS were merged into one group, the Women Airforce Service Pilots. Jacqueline Cochran was appointed Director of Women Pilots, and Nancy Love was appointed to the staff of the Ferrying Division of the Air Transport Command as advisor on WASP matters relating to ferrying.

Upon graduation from the training course, the WASPS were assigned to the air force or command in which they were needed. They were limited, however, to the continental U.S. and Canada. Their duties were principally ferrying, target towing, tracking and searchlight missions, simulated strafing, smoke laying and other chemical missions, radio control flying, basic and instrument instruction, engineering test flying, and administrative and utility flying.

In October 1943, WASPs were assigned to B-17s, B-26s, and B-25s. Some of them later flew such aircraft as P-47s and B-29s, formerly considered too difficult for women to handle.

Other preconceptions relating to women's limitations as pilots were discounted as a result of medical research conducted throughout the program. Three medical corps officers and eight



WASPs, flying Lockheed Lodestars, tow Waco Cg-4 gliders at South Plains Army Air Field, Lubbock, Texas, October 1943.

medical enlisted men were assigned to the training facility. They determined that the fatigue factor was no higher for women than for men. In fact, WASPs doing ferry work lost less time for physical reasons than did their male counterparts, and they were able to fly even the heavier aircraft, such as B-29s.

Early in 1944, Congress decided to militarize the WASPs. Because they were being assigned in large numbers to operational bases, they were treated as Army Air Force personnel. Also, the women, as an auxiliary group, did not have a schedule of advancement, no government insurance or hospitalization, and no set pay scale.

Unfortunately, the bill reached Congress when there was a job cutback in the Army flight training program, and male civilian flight instructors, pilots, and students in the War Training Service were losing their jobs. As a result, the House Committee on Civil Service recommended that no more WASPs be accepted for training, and the Army Air Forces officially terminated the training program.

By this time the war outcome also looked brighter. The entire flying cadet program was cut back, and pilots returning from abroad were available for domestic duties.

Jacqueline Cochran toured 50 bases where WASPs were stationed in the summer of 1944. Because of the failure of the militarization bill to pass Congress and because of the ending of the training program, she concurred with the recommendation that the WASPs be deactivated. The order was issued October 3, 1944, and deactivation occurred December 20.

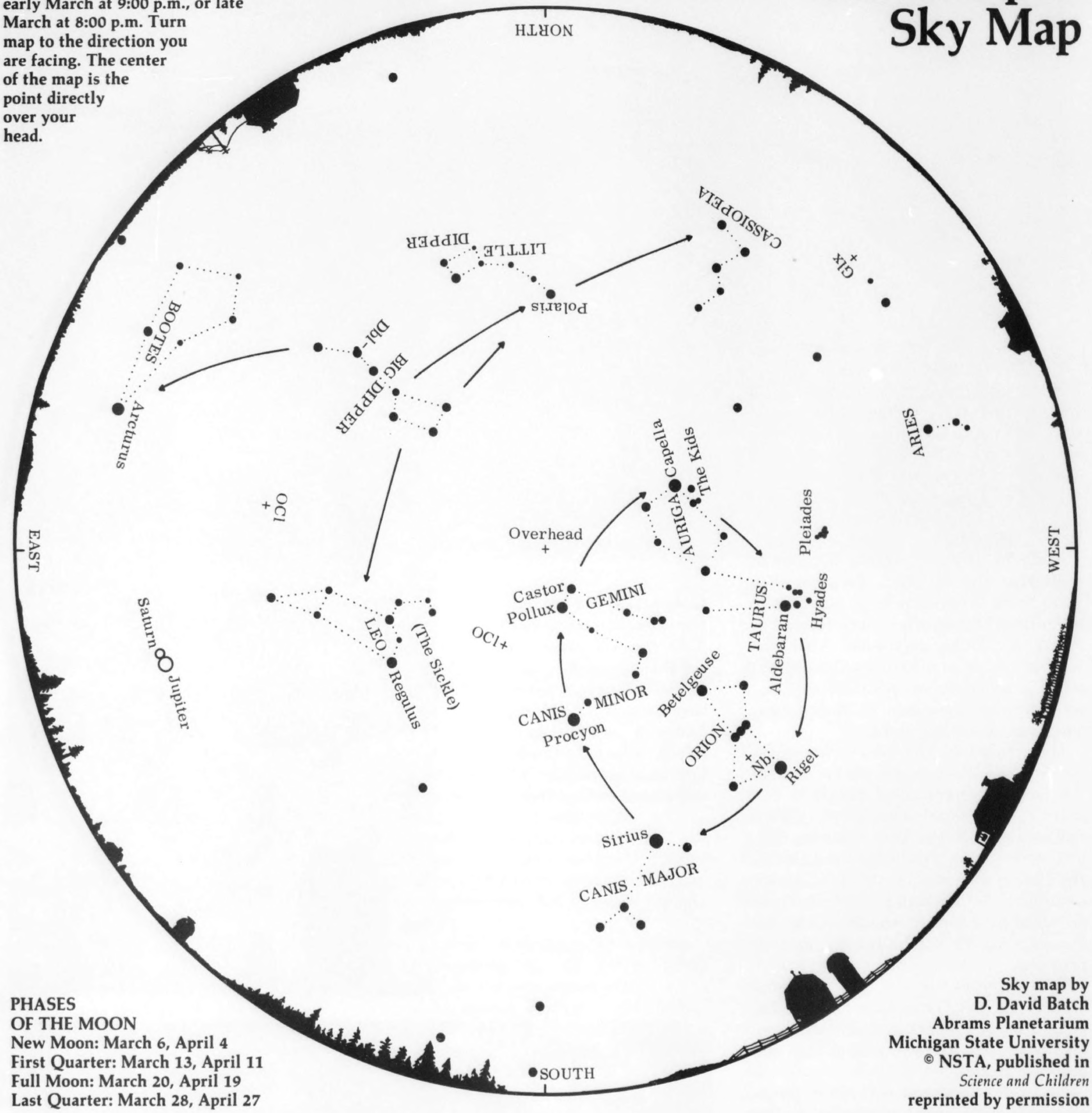
Of the 1830 women accepted into the WASP program, 1074 actually graduated, and 900 of these remained at the time of deactivation. Only 38 WASPs lost their lives during the program, and WASP pilots logged 60 million miles during its relatively brief existence. ■

In the summer of 1944, the first two women ever to fly a B-29, Dorothea Johnson (left) and Dora Dougherty, pose in front of their airplane with their instructor, Lt. Col. Paul Tibbets, Jr., who later became the pilot of the B-29 Enola Gay *which dropped the atomic bomb on Hiroshima.*

WASPs received training in engine and aircraft components as well as flight training. With Ground Instructor R.J. Patterson at Avenger Field are: Helen Dettweiler, Florence Anageros, and Dale Dailey.

March-April Sky Map

This circle represents the night sky as it appears in late February at 10:00 p.m., early March at 9:00 p.m., or late March at 8:00 p.m. Turn map to the direction you are facing. The center of the map is the point directly over your head.


NORTH
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LITTLE DIPPER
Polaris
Gl×
BOOTES
Dbl
BIG DIPPER
Arcturus
ARIES
Capella
The Kids
AURIGA
Pleiades
OCl
EAST
WEST
Overhead
Castor
Pollux
GEMINI
OCl
LEO
(The Sickle)
Regulus
Saturn
Jupiter
TAURUS
Hyades
Aldebaran
Betelgeuse
CANIS
MINOR
Procyon
ORION
Nb
Rigel
Sirius
CANIS MAJOR
SOUTH

PHASES OF THE MOON
New Moon: March 6, April 4
First Quarter: March 13, April 11
Full Moon: March 20, April 19
Last Quarter: March 28, April 27

Sky map by
D. David Batch
Abrams Planetarium
Michigan State University
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by T.H. Callen II
Production Specialist
Albert Einstein Spacearium, NASM

March 4 marks the midpoint of the Great Conjunction, a triple, between Jupiter and Saturn. A conjunction occurs when one celestial object appears to pass as another celestial object in the sky.

When two planets are in conjunction, they are usually very close together; this one, between the two largest gas giants of the solar system, is no exception. During a 9-1/2 month period, from mid-November 1980 to late August 1981, they will be no farther apart than 3°, six times the diameter of the Full Moon.

Jupiter, moving eastward along its orbit faster than Saturn, overtook Saturn, passing very close on December 31, 1980, marking the first conjunction. By early February 1981, both planets had begun to move backwards, or retrograde, an effect caused by the faster orbiting Earth overtaking them, passing between these planets and the Sun. On March 4, Jupiter will appear to have backed up enough to pass Saturn for a second conjunction. After May 18, Jupiter and Saturn will have resumed their normal eastward, or prograde, motion. The Jovian giant will overtake Saturn one more time for the final conjunction on July 23. The next triple conjunction between these two will not occur for 2-1/2 centuries, over the years 2238-39.

The southwestern skies show what is often called the Winter Ellipse, a football-like group of bright stars, whose length covers over 60°. In order of apparent brightness, the stars are Sirius, Capella, Rigel, Procyon, Aldebaran, Pollux, and Castor.

Regional Resource Program Applications Sought

The Regional Resource Persons Program is a NASM outreach program designed to prepare educators to give presentations in their respective geographic regions on major aerospace developments as exhibited in the Museum's galleries and special activities.

The next Training Session for new participants will be held in late July 1981, and will include topics on aviation and space exploration. NASM will provide to Regional Resource Persons support material such as slides, catalogues, and selected publications, plus limited public relations assistance. Participants will be responsible for their own transportation and expenses during the Training Session.

Persons interested in participating in this program should contact Janet K. Wolfe, Acting Chief, Education Services Division, National Air and Space Museum, Smithsonian Institution, Washington, DC, 20560, (202) 357-1504. Applications must be received by April 24, 1981; notification of selection will be made the week of May 11, 1981.

Assistance for the Hearing Impaired

The Education Services Division at NASM has acquired a Telecommunication Device for the Deaf (TDD). This machine enables a hearing-impaired individual to call the NASM museum and receive information about tours and tour scheduling. The machine has a 24-hour answering service. All messages are returned during business hours. The telephone number for the TDD is (202) 357-2853 (non voice). Those wishing general tour and scheduling information should call (202) 357-1400 (voice).

ILLUSTRATION CREDITS
Front cover, top, British Aerospace Aircraft Group; bottom, NASA. Page 3, U.S. Air Force. Page 5, NASA. Pages 6-9, Jet Propulsion Laboratory. All other photos, NASM.

New Aviation Books from NASM

Messerschmitt Me 262: Arrow to the Future by Walter J. Boyne

The Messerschmitt Me 262 was the world's first operational, mass produced jet aircraft. Introduced by the Germans late in World War II, its appearance ushered in the jet age.

NASM's Walter Boyne relates the dramatic story of this revolutionary aircraft, which will be on display in the Museum's Jet Aviation Gallery (see page 14). Behind the Me 262's combat career is a fascinating chain of events which led to its production. The Me 262 eclipsed the performance of all contemporary aircraft, and amazingly, Hitler first used it as a bomber, rather than as a combat aircraft.

Messerschmitt
Me 262
Arrow to the Future
WALTER J. BOYNE
THE NATIONAL AIR AND SPACE MUSEUM

The book also tells the story of the people who flew the Me 262 in combat. There are German narratives which are complemented by the accounts of the Americans who flew against the astonishing new jet—for instance, the team of crack USAAF pilots known as "Watson's Whizzers" who literally stole a fleet of jet aircraft from German airfields at the end of the war.

Also described are the postwar efforts to test and preserve the Me 262, including the painstaking work done at the Smithsonian's Paul E. Garber Facility to restore the aircraft to its pristine condition for exhibition in the Museum.

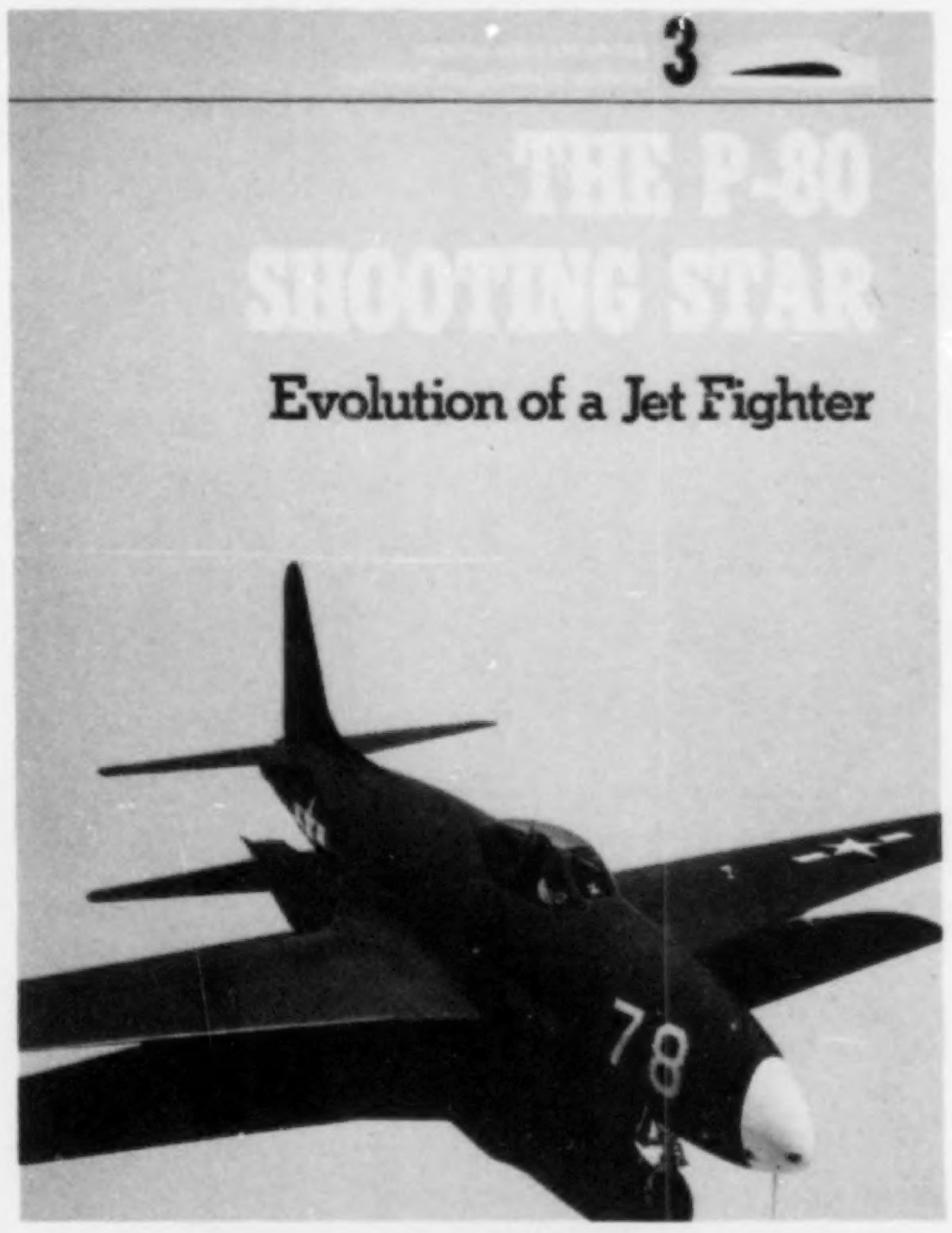
Destined to become a standard work about this important aircraft, the book is illustrated with more than 100 photographs, including operational photos from World War II and shots of the restored Me 262, many of them never before published.

Cloth, $19.95; 188 pages; 8½ x 10½ inches. Paper, $9.95.

The P-80 Shooting Star: Evolution of a Jet Fighter by E.T. Wooldridge, Jr.
Third book in the Famous Aircraft of the National Air and Space Museum series

In the spring of 1943, the Allies began a crash program to design an American jet fighter, the P-80. This book relates the story of that development which saw the construction of the P-80 in just 143 days by a Lockheed Aircraft Corporation team.

The P-80—nicknamed "Lulu-Belle"—went on to establish performance records against which all other contemporary jet fighters were measured. World War II ended before the P-80 series flew combat missions, but they established aviation records in post-War flights and they saw continuous action during the Korean War.



The book contains more than 160 photos, many of them dealing with the plane's unusual design, and there is a detailed account of the restoration of "Lulu-Belle" by NASM's craftsmen.

Paper, $5.95; 112 pages; 8½ x 11 inches.

To order these books, and to obtain free information about the National Air and Space Museum's other hardbound and paperback books and posters on aviation and space subjects, write to Program Coordinator, Dept. AS-1180, Room P-701, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560.

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